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Total Maximum Daily Loads
For Pathogen Indicators
Big Sioux River, Iowa

2005

Iowa Department of Natural Resources
Watershed Improvement Section

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1. Summary

Table 1.1 Big Sioux River TMDL Summary

Waterbody Name:	Big Sioux River (BSR), five contiguous impaired segments (see Table 1.2)
Use Designation Classes, all impaired segments:	Class A, recreational Class B (WW), aquatic life
Major River Basin:	Big Sioux River Basin
Pollutants:	Pathogen indicator, *E. coli* bacteria
Pollutant Sources:	Point, Nonpoint
Impaired Use:	Recreational Primary Contact, March 15 to November 15
Watershed Area: Total Iowa South Dakota Minnesota	 9,570 square miles 1,436 square miles 6,603 square miles 1,531 square miles
Stream Length: Iowa/Minnesota border to Missouri confluence	125 miles
Target: Pathogen Indicator Concentration:	The targets for all five of the Big Sioux River segments are the Iowa Water Quality Standard (WQS) numeric limits for *E. coli,* a geometric mean of 126 E. coli organisms/100 ml or a sample maximum of 235 *E. coli* organisms /100ml
Wasteload Allocations (WLA)*:	The wasteload allocations for this report can be found in the following tables in Section 3. BSRTMDL**-1: 3.15 and 3.16 BSRTMDL-2: 3.29 BSRTMDL-3: 3.49, 3.50, and 3.51 BSRTMDL-4: 3.72
Load allocations, existing loads, and load reductions needed to achieve target concentrations *:	The load allocations, existing loads, and load reductions for this report can be found in the following tables in section 3. BSRTMDL-1: 3.17 to 3.20 BSRTMDL-2: 3.30 to 3.33 BSRTMDL-3: Rock River: 3.52 to 3.55 Minnesota border: 3.56 to 3.58 BSR direct: 3.59 to 3.62 BSRTMDL-4: 3.73 to 3.76 BSRTMDL-5: 3.85 to 3.88

*Note on tables. Bacteria counts tend to get very large very quickly. The values in the tables of loads and allocations for the TMDLs in this document as well as in the associated spreadsheets are in scientific notation for ease of use and legibility. As a guide: 10E+3 = one thousand, 10E+6 = one million, 10E+9 = one billion, 10E+12 = one trillion, and so on.

**The five impaired waterbody segments are identified by a label consisting of the prefix BSRTMDL (Big Sioux River TMDL) followed by the segment number (1-5).

1.1 Introduction

This report consists of a Total Maximum Daily Load (TMDL) for each of five contiguous segments of the Big Sioux River. These segments are listed in Table 1.2.

Table 1.2. Five Impaired Segments requiring TMDLs

Big Sioux Impaired Segment	**Segment description**	**Segment length**	**Iowa Counties**
IA 06-BSR-0020-segments 2 and 3 (BSRTMDL-1)	Minnesota/Iowa border to Beaver Creek	29.23 miles	Lyon
IA 06-BSR-0020-segment 1 (BSRTMDL-2)	Beaver Creek to Rock River	25.26 miles	Lyon and Sioux
IA 06-BSR-0010-segment 4 (BSRTMDL-3)	Rock River to Indian Creek	21.35 miles	Sioux, Osceola, and Plymouth
IA 06-BSR-0010-segment 3 (BSRTMDL-4)	Indian Creek to Brule Creek	26.58 miles	Plymouth
IA 06-BSR-0010- segments 1 and 2 (BSRTMDL-5)	Brule Creek to Missouri River confluence	34.72 miles	Plymouth and Woodbury

The BSRTMDL-1 segment runs 29.23 miles from the Minnesota/Iowa border to Beaver Creek. The Iowa part includes eight directly draining HUC 12 sub-watersheds and four wastewater treatment plants. The larger Iowa tributaries draining to the Big Sioux are Blood Run and Klondike Creek.

The BSRTMDL-2 segment runs 25.26 miles from Beaver Creek to the Rock River. The Iowa part includes a single directly draining HUC 12 sub-watershed and no wastewater treatment plants. Nelson Creek and two unnamed streams drain this sub-watershed.

The BSRTMDL-3 segment runs 21.35 miles from the Rock River to Indian Creek. The entire Rock River watershed, consisting of 23 HUC 12 sub-watersheds in Iowa and a similarly sized area in Minnesota, drains to this Big Sioux River segment. In addition to the Rock River watershed, there are seven Iowa HUC 12 sub-watersheds that discharge directly to the Big Sioux River from this segment's watershed. The Minnesota part of the Rock River watershed is drained by three streams that cross the state border. From east to west, they are the Little Rock River, the mainstem of the Rock River, and Mud Creek. The Little Rock River and Mud Creek flow into the Rock River 26 miles and 27 miles upstream from the Big Sioux River, respectively. There are eleven wastewater treatment plants in the Iowa part of the Rock River watershed and one that discharges directly to the Big Sioux River. Besides the Rock River, there are two streams that flow into this segment of the Big Sioux, Dry Creek and Sixmile Creek.

The BSRTMDL-4 segment runs 27.58 miles from Indian Creek to Brule Creek. The Iowa part includes four HUC 12 sub-watersheds and three wastewater treatment plants. Indian and Westfield Creeks drain this sub-watershed.

The BSRTMDL-5 segment runs 35.72 miles from Brule Creek to the confluence with the Missouri River. The Iowa part includes five HUC 12 sub-watersheds and no wastewater treatment plants. Broken Kettle and Rock Creeks drain this watershed.

Background: The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a TMDL for waters that have been identified on the state's 303(d) list as impaired by a pollutant. Five segments of the Big Sioux River have been identified as impaired by the pathogen indicator *E. coli* (Table 1.2). The purpose of these Big Sioux River TMDL's is to estimate the maximum pathogen indicator "loads" that can be delivered from the watershed and still meet the Iowa Water Quality Standards (WQS). Complying with the WQS limits for *E. coli* will provide full support for the river's designated recreational uses.

TMDL development and implementation is often an iterative process that requires re-evaluation of existing information, analysis of new data as it becomes available, and the refinement of analytical procedures. This process is frequently referred to as phasing. Phasing TMDL's is an approach to managing water quality used when the origin, nature and sources of water quality impairments are not completely understood. In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the resources and information available.

The five TMDLs presented in this report represent Phase 1 in the development of a project to improve Big Sioux River water quality. The evaluation process will continue as more data and the resources to analyze it are made available, allowing for improved understanding of the specific problems that are causing the impairment. This will lead to stakeholder driven solutions and more effective management practices. Continued monitoring will help determine what management practices result in load reductions and the attainment of water quality standards. These monitoring activities are continuing components of the ambient monitoring programs of the states of Iowa and South Dakota and will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

The first phase of these TMDLs sets specific and quantified targets for pathogen indicator concentrations in the river and allocates allowable loads to all sources. Phase 2 will consist of implementing the follow-up monitoring plan, evaluating collected data, and readjusting the allocations and management practices, if needed.

Calculating Total Maximum Daily Load. There are three components to a TMDL: the wasteload allocation (WLA) for permitted point sources like wastewater treatment plants (wwtp); load allocations for non-point sources; and a margin of safety to account for uncertainty in the estimates for the wasteload and load allocations.

- Wasteload Allocations. The wwtp wasteload allocations for each of the three TMDL segments that include wastewater treatment plants in their watersheds are in the Section 3 Tables 3.15 and 3.16 (BSRTMDL-1), 3.48 and 3.49 (BSRTMDL-3), and 3.70 and 3.71 (BSRTMDL-4). The watersheds of segments BSRTMDL-2 and BSRTMDL-5 do not include any permitted facilities requiring a WLA.

  The WLA's are for two stream design conditions, "low" and "very low" flow, described in Appendix B, Assumptions and Procedures. Continuous discharge facilities have WLA's at both design conditions while controlled discharge lagoons do not discharge at "very low" stream flow. The WLA concentrations higher than the water quality standard (WQS) concentration are the result of calculating the bacterial die-off from the time the indicator bacteria transit from the plant discharge location to the impaired Big Sioux River segment.

  The BSRTMDL-3 segment includes the Rock River watershed as well as seven HUC 12 sub-watersheds that discharge directly into the Big Sioux River. WLA's for all of the Iowa permitted wastewater treatment plants in the Rock watershed are included in BSRTMDL-3. The City of Hawarden wastewater treatment plant discharges directly into the Big Sioux River and already has a bacteria WLA that requires it to disinfect plant effluent and comply with the WQS.

- Load Allocations. The *E. coli* load allocations for all non-point sources are based on four percentile ranked design flow conditions. The percentile rank is how frequently the stream flow is as high or higher than a given flow value. The four percentile ranks used are 1%, 10%, 50%, and 70%, which represent flows that are exceeded 1%, 10%, 50%, and 70% of the time, respectively. Evaluation of monitoring data with load duration curves showed that the Iowa Big Sioux River tributaries had indicator bacteria concentrations that significantly exceeded the WQS throughout most flow conditions. The load allocations are based on all tributaries meeting the WQS at their confluences with the Big Sioux River.

  There are 48 HUC 12 sub-watersheds in the Iowa Big Sioux River watershed. Of these, 23 are in the Rock River watershed and 25 directly drain into the Big Sioux River (BSR). The HUC 12 discharge locations have been identified and the total distance from the discharges to the impaired BSR segments has been measured. This information has been used to calculate bacteria *die-off* from the sub-watershed discharge location to the BSR and this is then incorporated into individual HUC 12 load allocations.

- Margin of Safety. The margin of safety (MOS) for these total maximum daily loads is implicit. The implicit MOS is the consequence of the frequent incorporation of conservative assumptions in the evaluations.

Note on South Dakota Watershed Load Allocations and Reductions: Explicit allocations and reductions for the South Dakota part of the Big Sioux River watershed have not been included because the South Dakota Department of Environment and Natural Resources (DENR) has not yet evaluated the flow and concentration data they collected. When this information becomes available allocations and reductions of existing loads will be made using the same methods and procedures used to derive the Iowa and Minnesota allocations and loads. The allocations will be based on design flows determined by load duration curve evaluation. The allocation at each of the design flows will be that which gives an *E. coli* sample maximum of 235-organisms per 100 milliliters. This value is from the Iowa Water Quality Standards for Class A1 Primary Recreational Use, which is impaired designated use for the Big Sioux River segments. The reductions will be the difference between the allowable load at the design flows and the existing load as directly measured through the SDDENR targeted monitoring program.

Required components. This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the Clean Water Act. These regulations and consequent TMDL development are summarized below:

1. **Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:** Five contiguous segments of the Big Sioux River are impaired. These segments include the entire Iowa Big Sioux River reach, from the Minnesota/Iowa Border to the confluence with the Missouri River.

2. **Identification of the pollutant and applicable water quality standards:** The pollutants causing the water quality impairments are pathogens that are measured by the bacterial indicators *E. coli* and fecal coliform. The designated uses for the Big Sioux River are Class A1, Primary Contact Recreation and Class B (WW), aquatic life.

3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:** The target of this TMDL is a reduction of pathogen indicator loading to the Iowa water quality standard numeric limits for Class A1 waterbodies. These limits are for *E. coli* from March 15th to November 15th and are for a geometric mean concentration of 126

organisms/100ml and a sample maximum of 235 organisms/100ml. In practice, these limits are often translated by IDNR to a fecal coliform geometric mean of 200 org/100 ml and a sample maximum concentration of 400 org/100 ml. This translation is often done for NPDES permits since there is not an EPA approved method of *E. coli* measurement.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody deviates from the pollutant load needed to attain and maintain water quality standards**: The water quality standard is for an *E. coli* geometric mean of 126 org/100 ml and a sample maximum of 235 org/100 ml. Specifics of the monitoring data used in the assessment of the impairment can be found in *Section 3.1, Problem Identification*.

5. **Identification of pollution source categories**: Both point and non-point sources of pathogen indicators have been identified as the cause of the primary contact recreation use impairment for three of the five impaired segments of the Big Sioux River. The remaining two segments, BSRTMDL-2 and BSRTMDL-5 have no point sources within their watersheds and non-point sources of pathogen indicators have been identified as the cause of the impairment.

6. **Wasteload allocations for pollutants from point sources**: The point source dischargers to the impaired segments of the Big Sioux River and the wasteload allocations to these point sources are listed in Tables 3.15 and 3.16 (BSRTMDL-1), 3.48 and 3.49 (BSRTMDL-3), and 3.70 and 3.71 (BSRTMDL-4).

7. **Load allocations for pollutants from nonpoint sources**: The load allocations for the Big Sioux River for the individual TMDLs can be found in the following tables:

    BSRTMDL-1: 3.17 to 3.20
    BSRTMDL-2: 3.29 to 3.32
    BSRTMDL-3:
        Rock River: 3.50 to 3.53
        Minnesota border: 3.54 to 3.56
        BSR direct: 3.57 to 3.60
    BSRTMDL-4: 3.72 to 3.75
    BSRTMDL-5: 3.84 to 3.87

8. **A margin of safety**: The Margins of Safety (MOS) for all of the TMDLs in this document are the same. The MOS has been incorporated through implicit conservative assumptions in the modeling and representation of point and non-point sources. For non-point sources, a conservative assumption is that die-off does not occur for bacteria originating in HUC 12's adjacent to the Big Sioux River or from the time of travel between the source within the sub-watershed and the HUC 12 discharge location. For

point sources, i.e., wastewater treatment facilities, it is assumed that the facility will monitor discharges for compliance with the water quality standards and disinfect as needed.

9. **Consideration of seasonal variation**: These TMDLs were developed based on the Iowa water quality standards primary contact recreation season that runs from March 15 to November 15. Seasonal variation in non-point source (NPS) livestock loading has been considered in the timing and distribution of manure in the BSR watershed.

10. **Allowance for reasonably foreseeable increases in pollutant loads**: No allowance for an increase in pathogen indicators has been included in these TMDLs because current watershed land uses are predominantly agricultural. The addition or deletion of animal feeding operations within the watershed could increase or decrease pathogen indicator loading. Because such events cannot be predicted or quantified at this time, a future allowance for their potential occurrence was not accounted for in these TMDLs.

11. **Implementation plan**: Although not required by the current regulations, an implementation plan is outlined in section 5 of this report.

2. Big Sioux River, Description and History

2.1 The Stream and its Hydrology

The Big Sioux River basin (Table 2.1) is located in far northwest Iowa, eastern South Dakota, and southwest Minnesota. The Big Sioux River forms the border between Iowa and South Dakota from the Iowa/Minnesota border to the Missouri River.

Table 2.1 Big Sioux River and its Basin Features

Waterbody Name:	Big Sioux River, seven assessment segments
Hydrologic Unit Code:	Big Sioux River – 10170203 Rock River - 10170204
IDNR Waterbody ID:	IA 06-BSR
Location:	S33, T92N, R49W to S25, T100N, R49W
Water Quality Standards and Designated Uses:	See Table 3.2
Major Tributaries (Iowa):	Rock River, Indian Creek
Receiving Waterbody:	Missouri River
Stream Segment Length (Iowa):	125 miles
Watershed Area: **Total** **Iowa** **South Dakota** **Minnesota**	 9,570 square miles 1,436 square miles 6,603 square miles 1,531 square miles

The Big Sioux River originates north of Watertown, South Dakota and flows generally south for 420 miles to its confluence with the Missouri River near Sioux City, Iowa. The Big Sioux River forms the boundary between South Dakota and Iowa from near Sioux Falls, SD to Sioux City, IA. Major tributaries to the Big Sioux in the Iowa reach include the Rock River, with a drainage area of 1,688 square miles, and Indian Creek with a drainage area of 63 square miles. The linear distance between Sioux City and Sioux Falls is 75 miles while the river distance is 125 miles. The meandering nature of the river creates a diversity of aquatic habitats. Most of the watershed on the Iowa side is used for agriculture, specifically row crops and livestock feeding operations, including open feedlots.

2.2 The Watershed

The total area of the Big Sioux River basin is about 9,570 square miles and the part that is in Iowa is about 1,436 square miles. The lower Big Sioux River watershed is located in the Northern Glaciated Plains and Western Corn Belt Plains ecoregions. The project area for this report is shown in Figure 1. A flat to gently rolling landscape composed of glacial drift characterizes the Northern Glaciated Plains ecoregion. The Western Corn Belt Plains ecoregion is composed of level to gently rolling glacial till plains with areas of moraine hills and loess deposits.

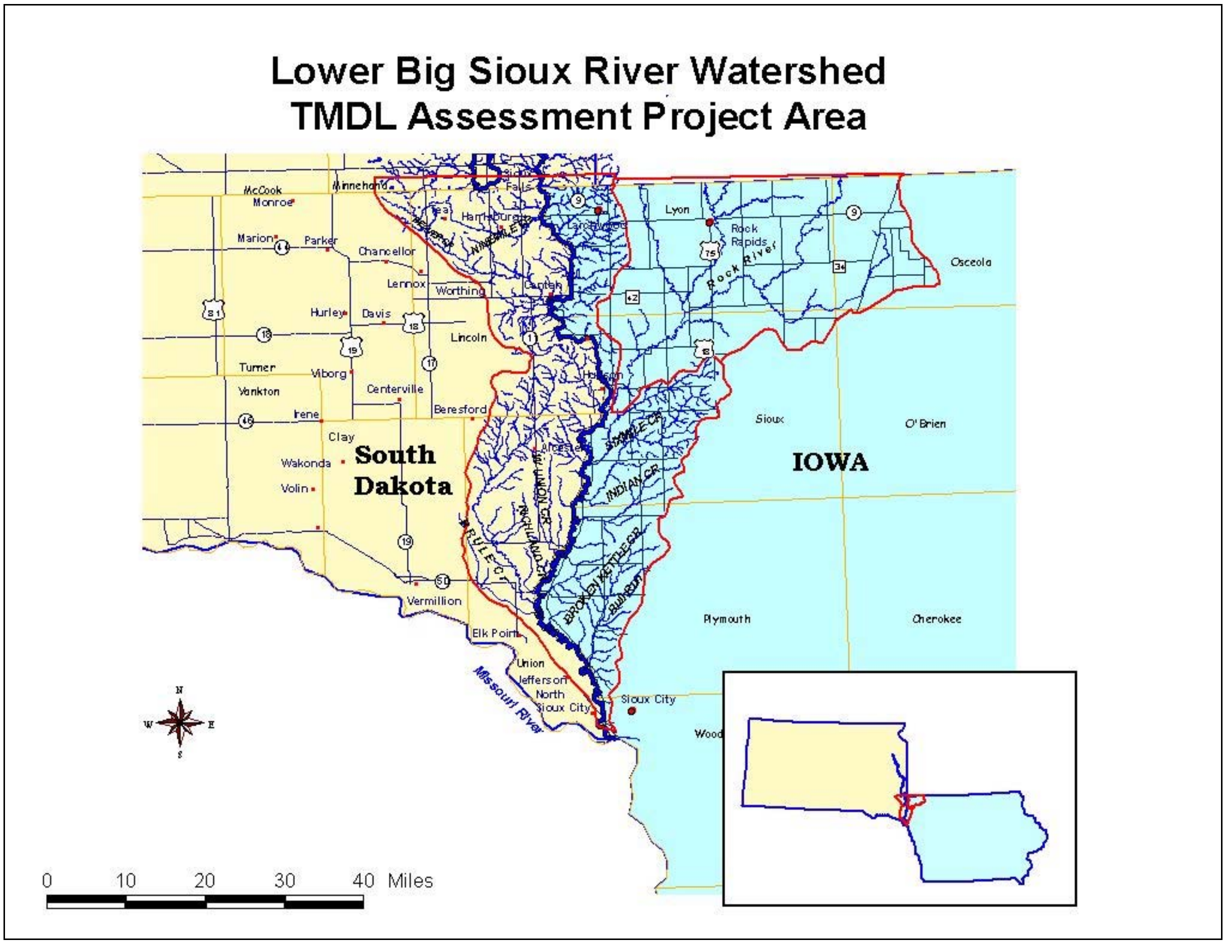

Figure 1. Big Sioux River Project Area

Agriculture is the primary land use in the project area including row crop farming, small grains, hay production and pastureland (Table 2.2). Livestock feeding operations are found throughout the watershed with beef and hog operations the most common. The average rainfall in the lower Big Sioux Watershed is approximately 25 inches per year with 78% falling during the growing season. The average annual snowfall is approximately 34 inches but varies widely from year to year. Wildlife species present in the area include whitetail deer, red fox, beavers, raccoons, ring-necked pheasants, mourning doves, and numerous other species of songbirds, waterfowl, reptiles and amphibians.

Table 2.2 2002 Landuse in the Iowa Big Sioux River watershed

Landuse	Area in Acres	Percent of Total Area
Row Crops	673,200	76.8
Grass or hay	172,700	19.7
Woods	15,800	1.8
Urban/artificial	10,500	1.2
Water	3,500	0.4
Barren	880	0.1
Total	876,580	100

2.2.1 Soils

In general, the soils in the Iowa part of the Big Sioux River watershed are alluvium in the river valleys, deep loess as you move further from the river that changes to shallow loess over glacial till. A regional soils map shows three soil regions in the Iowa watershed. These are:

- Semi arid area of loess over glacial till, Moody-Trent Association; most of Lyon County and northwest Sioux County.
- Loess over till, Galva-Primghar-Steinaur Association; eastern Lyon County and most of Sioux County.
- Thin loess over Tazewell till, Sac-Everly-Wilmonton Association; far eastern Lyon County into Osceola County.
- Loess over till, Ida-Galva Association, northwest Plymouth County; Ida-Hamburg southwest Plymouth County; Galva-Ida to Ida-Monona north central to south central Plymouth County.

The stream bottomland and bench soils are nearly level to gently sloping silty soils formed in loess and alluvium. County by county from south to north in the three counties along the Big Sioux River Iowa watershed the descriptions of the major soil groups are:

- Plymouth County – gently sloping to very steep well drained silt; level to strongly sloping well drained silt.
- Sioux County - gently sloping to strongly sloping well drained silty soils formed in loess; nearly level to moderately sloping well to somewhat poorly drained silt formed in loess and alluvium; nearly level to strongly sloping well drained silty soils formed in loess.
- Lyon County - nearly level to strongly sloping well drained silty soils formed in loess; nearly level to moderately sloping well drained to somewhat poorly drained moderately fine textured soil.

2.2.2 Livestock Feeding Operations

The Big Sioux River watershed, and northwest Iowa in general, is a region with one of the highest concentrations of livestock feeding operations in the state. Some of these are confined animal feeding operations (CAFO) and many others are open feedlots.

A landuse assessment based on aerial infrared photography was completed in June 2005 by the IDNR. This shows that the major landuse is row crop, that pasture and forage crops are significant landuses, and there are large numbers of CAFOs and active and inactive open feedlots within the Iowa watershed.

CAFO's are operations where animals are kept in totally roofed areas. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. Pathogen indicators, oxygen demanding substances, and nutrients from CAFOs are delivered via runoff from land-applied manure or from leaking/failing storage structures.

Open feedlots are unroofed or partially roofed animal feeding operations in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation. Runoff from open feedlots can deliver substantial quantities of pathogen indicators, nutrients and oxygen demanding materials. Waterbody proximity, livestock numbers and type affect delivery and impact of these constituents, whether or not water is diverted around the feedlot facility when it rains, the efficiency of controls on manure in runoff, and how well these are maintained.

Feedlots with more than one thousand head capacity are registered with IDNR and are required under an agreement with EPA to provide complete control over discharges from their operations or reduce capacity under 1000 head in 2006. These feedlots are considered point sources under EPA rules.

3. Big Sioux River TMDLs for Pathogen Indicators

3.1 Problem Identification

The 1998 Iowa Section 305b Assessment Report divided the part of the Big Sioux River that borders Iowa into two segments. The first segment was 82 miles long and extended from the Missouri River confluence to the Rock River confluence. The second segment was 54 miles long and ran from the Rock River to the Iowa/Minnesota border. Both segments had the same designated uses; Class A, Primary Contact Recreation, and Class B, Warm Water Aquatic Life.

The 2002 305b assessment for the Big Sioux River, which is the basis for these TMDLs, subdivides the same two reaches into 7 segments as shown in Figure 2 and Table 3.1.

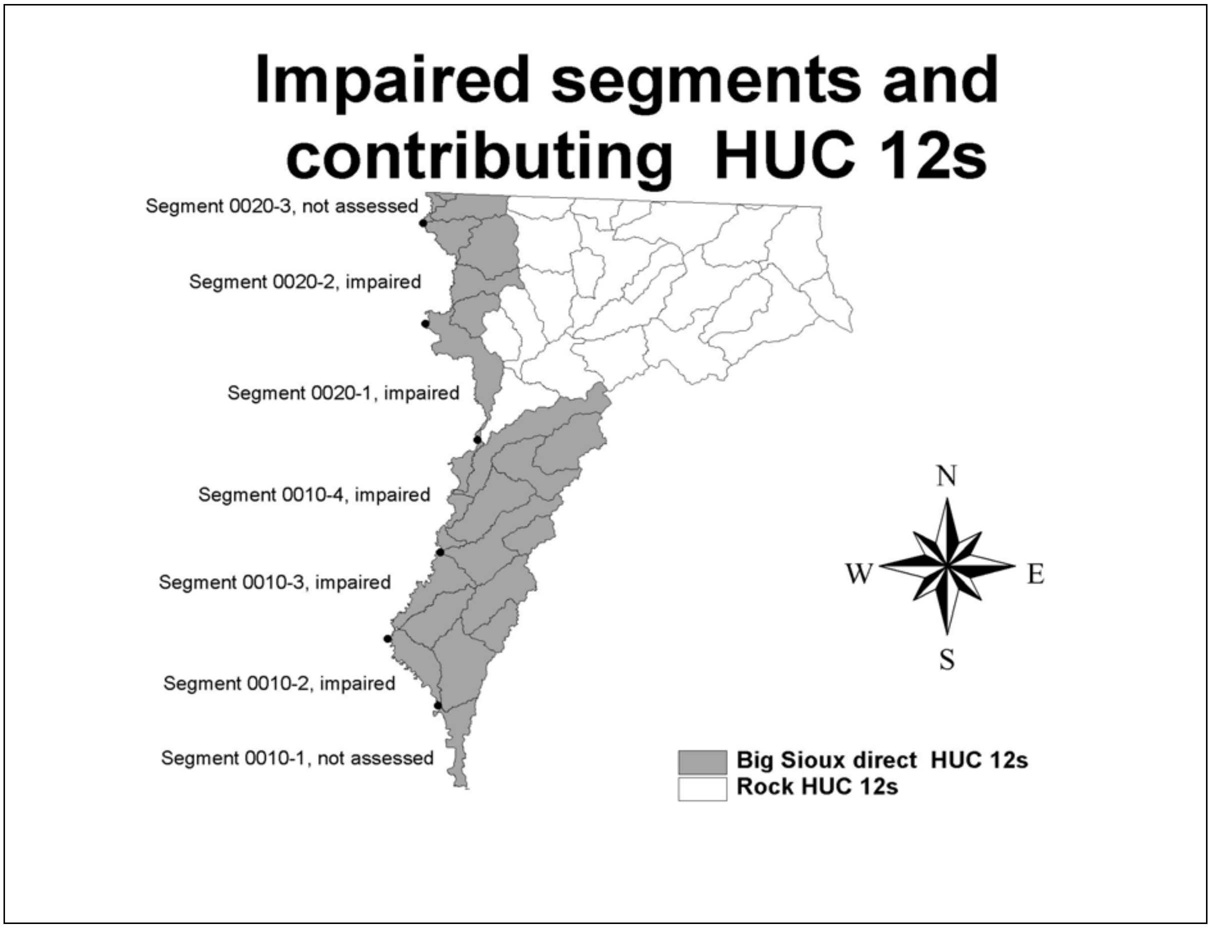

Figure 2. Impaired Segments and Contributing HUC 12 Sub-watersheds

Table 3.1 Big Sioux River Assessment Reach and Segment Designations.

Reach	Segment	Length, miles	Description
0010	1	16.9	Mouth to Broken Kettle Creek, not assessed
0010	2	18.4	Broken Kettle Creek to Brule Creek, impaired
0010	3	22.8	Brule Creek to Indian Creek, impaired
0010	4	23.7	Indian Creek to Rock River, impaired
0020	1	22.2	Rock River to Beaver Creek, impaired
0020	2	22.5	Beaver Creek to Ninemile Creek, impaired
0020	3	9.25	Ninemile Creek to the IA/MN border, not assessed

The following paragraphs are the basis for the 2002 305b impaired assessment for the five contiguous impaired Big Sioux River segments. These five segments were included on the 2002 Iowa 303d list of impaired waters. The 2002 water quality assessment used fecal coliform as the pathogen indicator bacteria because at the time it was the pathogen indicator in the WQS. Since then the WQS pathogen indicator has been changed to *E. coli* and this new standard is used in this report unless otherwise noted.

For purposes of Section 305(b) assessments, DNR uses the long-term average monthly flow plus one standard deviation of this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 orgs/100 ml) does not apply "when the waters are materially affected by surface runoff."

<u>Reach 0010</u>: For the 2002 report, the previous waterbody segment for the Big Sioux River (IA 06-BSR-0010-0), which extended 82 miles from its mouth at Sioux City to confluence with the Rock River in Sioux County, was split into four sub segments: (1) mouth to Broken Kettle Creek in southwestern Plymouth County (IA 06-BSR-0010-1), (2) Broken Kettle Creek to Brule Creek near Richland, SD (and near Westfield, IA) (IA 06-BSR-0010-2), (3) Brule Creek to Indian Creek in northwestern Plymouth Co. (IA 06-BSR-0010-3), and (4) Indian Creek to the Rock River in Sioux Co. (IA 06-BSR-0010-4).

- *<u>Reach 0010, Segment 2</u>: See segment 3 for assessment information. Listed as impaired in 2002.*

- *<u>Reach 0010, Segment 3</u>: The Class A (primary contact recreation) uses are assessed (monitored) as "not supported." The data for this assessment is monthly Big Sioux River monitoring done near Richland, SD, by the South Dakota Department of Environment and Natural Resources (DENR) from November 1999 through September 2001. The fecal coliform 10 sample geometric mean not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Richland station exceeded the primary contact criterion. The fecal coliform geometric mean was 291-organisms/100 ml, with five samples (50%) exceeding the EPA-recommended single-sample maximum value of 400-organisms/100 ml. According to U.S. EPA guidelines, if the geometric mean level of fecal coliforms exceeds 200 orgs/100 ml, the primary contact recreation uses are "not supported".*

- *<u>Reach 0010, Segment 4</u>: The Class A (primary contact recreation) uses are assessed (monitored) as "not supported." The data for this assessment is monthly Big Sioux River monitoring done near Alcester, SD, by the South Dakota Department of Environment and Natural Resources (DENR) from November 1999 through September 2001. The fecal coliform 8 sample geometric mean not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Alcester station exceeded the primary contact criterion. The fecal coliform geometric mean was 448-organisms/100 ml, with three samples (38%) exceeding the EPA-recommended single-sample maximum value of 400-organisms/100 ml. According to U.S. EPA guidelines, if the geometric mean level of fecal coliform exceeds 200-organisms/100 ml, the primary contact recreation uses are "not supported".*

<u>Reach 0020</u>: For the 2002 report, the previous waterbody segment for the Big Sioux River (IA 06-BSR-0020-0), which extended 54 miles from its confluence with the Rock River in Sioux County to the Iowa/Minnesota state line, was split into three sub segments: (1) from Rock River to Beaver Creek near Canton, SD and Beloit, IA (IA 06-BSR-0020-1), (2) Beaver

Creek to Ninemile Creek ENE of Harrisburg, SD and west of Larchwood, IA (IA 06-BSR-0020-2), and (3) Ninemile Creek to the Iowa Minnesota state line (IA 06-BSR-0020-3).

- *<u>Reach 0020, Segment 1</u>: The Class A uses are assessed (evaluated) as "partially supported." The data for this assessment is monthly Big Sioux River monitoring done near Hudson, SD, by the South Dakota Department of Environment and Natural Resources (DENR) from November 1999 through September 2001. The geometric mean of indicator bacteria (fecal coliforms) in the 7 samples not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Canton monitoring station was below the Iowa water quality criterion (200 fecal coliform orgs/100ml) to protect primary contact recreation uses; the percentage of samples that exceeded the U.S. EPA-recommended single-sample maximum value, however, suggests "partial support" of the Class A uses. For purposes of Section 305(b) assessments, DNR uses the long-term average monthly flow plus one standard deviation of this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 orgs/100 ml) does not apply "when the waters are materially affected by surface runoff." The geometric mean of fecal coliform bacteria in the 7 non-runoff-affected samples was 111 orgs/100 ml, with two samples (29%) exceeding the EPA-recommended single-sample maximum value of 400 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting, if more than 10% of the samples exceed the single-sample maximum value of 400 orgs/100 ml, the primary contact recreation uses are "partially supported" (see pgs 3-33 to 3-35of U.S. EPA 1997b). Because less than 10 non-flow affected samples were available for this assessment, the assessment type is considered "evaluated"; thus, this assessment is not of sufficient quality to support a Section 303(d) listing.*

Note: The 2004 305b assessment for this segment has determined that it is impaired, as did the 1998 assessment.

- *<u>Reach 0020, Segment 2</u>: The Class A uses were assessed (evaluated) as "partially supported." The geometric mean of indicator bacteria (fecal coliforms) in the 7 samples not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Canton monitoring station was below the Iowa water quality criterion (200 fecal coliform orgs/100ml) to protect primary contact recreation uses; the percentage of samples that exceeded the U.S. EPA-recommended single-sample maximum value, however, suggests "partial support" of the Class A uses. For purposes of Section 305(b) assessments, DNR uses the long-term average monthly flow plus one standard deviation of this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 orgs/100 ml) does not apply "when the waters are materially affected by surface runoff." The geometric mean of fecal coliform bacteria in the 7 non-runoff-affected samples was 111 orgs/100 ml, with two samples (29%) exceeding the EPA-recommended single-sample maximum value of 400 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting, if more than 10% of the samples exceed the single-sample maximum value of 400 orgs/100 ml, the primary contact recreation uses are "partially supported" (see pgs 3-33 to 3-35of U.S. EPA 1997b). Because less than 10 non-flow affected samples were available for this assessment, the assessment type is considered "evaluated"; thus, this assessment is not of sufficient quality to support a Section 303(d) listing.*

Note: The 2004 305b assessment for this segment has determined that it is impaired, as did the 1998 assessment.

Pathogen indicator bacteria sources can include runoff from fields where manure has been applied, pastures where livestock graze, open feedlots, wastewater treatment plant discharges, urban stormwater run-off, failed onsite systems (septic tanks), and wildlife. Non-point source pathogen problems are usually the consequence of runoff from rainfall. Material containing bacteria is transported by runoff to streams causing high bacteria counts when stream flows are high. There are some non-point sources, such as grazing cattle in streams and some wildlife, that act like point sources in that a pathogen load is delivered to the stream without a precipitation event for transport.

Sources that continuously discharge to a stream are point sources, such as wastewater treatment plants and failed septic tank systems. Wastewater treatment plants that discharge directly into waters designated Class A Primary Contact Recreational Use are required to meet the water quality criterion at their discharge and usually do this by disinfecting plant effluent.

3.1.2 Impaired Beneficial Uses and Applicable Water Quality Standards

The applicable designated uses and water quality standards for pathogen indicators are found in *Iowa Administrative Code 567, Chapter 61, Water Quality Standards.*

> *61.3(3)a. Class "A" waters. Waters which are designated as Class "A1," "A2," or "A3" in subrule 61.3(5) are to be protected for primary contact, secondary contact, and children's recreational uses. The general criteria of subrule 61.3(2) and the following specific criteria apply to all Class "A" waters.*
> *(1) The Escherichia coli (E. coli) content shall not exceed the levels noted in the Bacteria Criteria Table when the Class "A1," "A2," or "A3" uses can reasonably be expected to occur.*

Table 3.2 E. coli Bacteria Criteria (organisms/100 ml of water)

Use	***Geometric Mean***	***Sample Maximum***
Class A1		
3/15 – 11/15	*126*	*235*
11/16 – 3/14	*Does not apply*	*Does not apply*
Class A2 *(Only)*		
3/15 – 11/15	*630*	*2880*
11/16 – 3/14	*Does not apply*	*Does not apply*
Class A2		
Year-Round	*630*	*2880*
Class A3		
3/15 - 11/15	*126*	*235*
11/16 - 3/14	*Does not apply*	*Does not apply*

Class A1 - Primary Contact Recreational Use.
Class A2 - Secondary Contact Recreational Use.
Class A3 - Children's Recreational Use.

When a water body is designated for more than one of the recreational uses, the most stringent criteria for the appropriate season shall apply.

3.1.3 Data Sources

Most of the water quality monitoring data used in the development of this TMDL project originates from four different but related monitoring programs and activities managed by the Iowa DNR and South Dakota DENR. These are:

<u>Iowa ambient monitoring program</u>. The Iowa ambient water quality monitoring program is a statewide network of monitoring sites intended to provide data for the assessment of the state's streams and lakes. There is only one ambient monitoring site in the Big Sioux River Iowa watershed and that is on the Rock River near Hawarden. Iowa does not do any ambient monitoring on the Big Sioux River itself.

<u>South Dakota ambient monitoring program</u>. The South Dakota DENR ambient water quality monitoring program also is a program providing statewide water quality monitoring data for assessment purposes. This program operates four monitoring sites on the Iowa reach of the Big Sioux River at Canton, Hudson, Alcester and Richland, all on the South Dakota side. Data collected at these four sites has been used by the IDNR for its biannual water quality assessments of the Big Sioux River.

<u>Iowa TMDL targeted water-monitoring program</u>. IDNR began targeted monitoring of the Iowa Big Sioux River tributaries including the Rock River and its major tributaries, in the early spring of 2002 through November of 2003. This monitoring plan consisted of monthly sampling at all of the eleven monitoring sites and the installation of seven autosamplers at seven tributary sites to collect data during precipitation events and to provide continuous water surface elevations that are used to estimate continuous flow rates.

Figure 3 shows the locations of the 11 Iowa TMDL monitoring sites. The autosamplers were installed at sites 5, 6, 7, 8, 9, 10, and 11. Monthly Sites 1, 3, and 4 are located where the Rock River and its two major tributaries, Mud Creek and Little Rock River, cross the border from Minnesota. Monthly Site 2 is located downstream of the City of Rock Rapids at the USGS gage. There is also a USGS gage at autosampler Site 7 in the City of Rock Valley. Hydrographs and data from these sites can be found in the Data and Model Development E-folder. An index of this folder can be found in Appendix A.

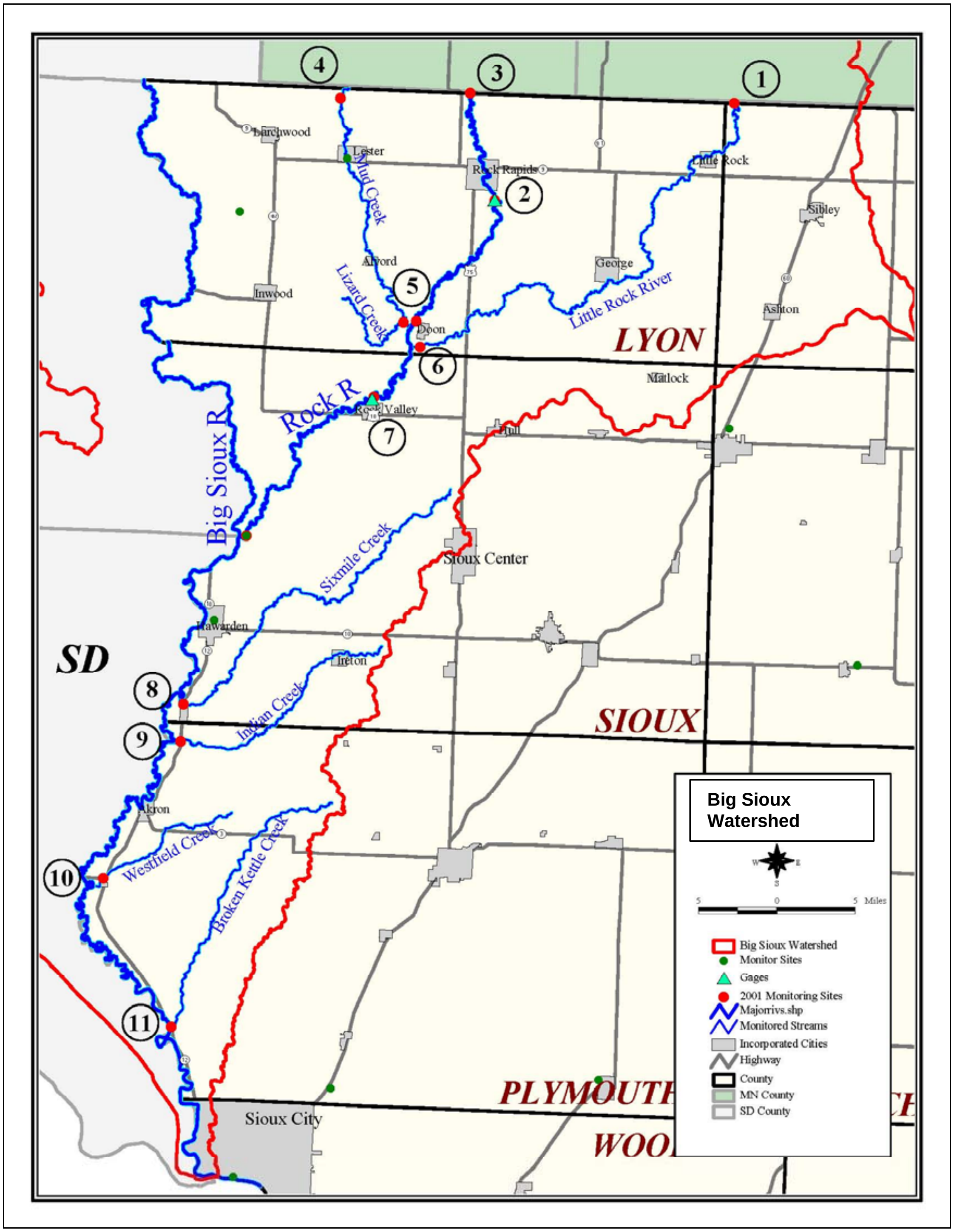

Figure 3. Iowa Targeted TMDL Monitoring Sites

<u>The South Dakota targeted water-monitoring program</u>. The SDDENR has been monitoring in the Lower Big Sioux River and its watershed at the same time as the Iowa TMDL targeted monitoring beginning in 2002. This monitoring program

includes 21 monitoring sites, 10 sites on the mainstem Big Sioux River and 11 sites on tributaries in the South Dakota portion of the watershed. Flow and load information provided by this monitoring data will be used to develop the South Dakota load allocations. The locations of files with the monitoring site listing and a map of their locations can be found in Appendix A.

U.S. Geological Survey (USGS) Gage Stations. There are two USGS flow gages on the Rock River and one on the Big Sioux River. These are located at Rock Rapids and Rock Valley on the Rock and at Akron on the Big Sioux. There are also two relevant gages on the Big Sioux in South Dakota, one in Sioux Falls at North Cliff Ave. and one on Split Rock Creek, a major tributary to the Big Sioux draining parts of South Dakota and Minnesota.

3.1.4 Interpreting Big Sioux River Water Quality Data

Load duration curves and statistical analysis have been used to establish the flow conditions where water quality standards violations occur. Load duration curves are derived from flow plotted as a percentage of their recurrence and pollutant loads calculated from pollutant concentrations and flow volume. Load duration methods have been applied to Iowa flow and water quality data for the four tributaries downstream of the Rock River: Sixmile Creek, Indian Creek, Westfield Creek, and Broken Kettle Creek. SDDENR will also be applying load duration curves to the South Dakota mainstem flow and concentration data.

3.1.5 Big Sioux River Water Quality Evaluation Plan and Organization

This document consists of five total maximum daily loads for the seven assessment segments of the Big Sioux River. Two of the TMDLs at the farthest upstream and downstream extents of the river, from the Iowa/Minnesota border to the confluence with the Missouri River, include two segments each. The reason for this is that the segment at the border and the segment at the Missouri confluence were categorized as not assessed due to insufficient data. These TMDLs are, in order from the border to the Missouri:

BSRTMDL-1: From the Iowa/Minnesota border to Beaver Creek, south of Canton, South Dakota, a distance of 47.04 km (29.23 miles). This includes two assessment segments.

BSRTMDL-2: From Beaver Creek to the Rock River, a distance of 40.65 km (25.26 miles).

BSRTMDL-3: From the Rock River to Indian Creek, a distance of 34.36 km (21.35 miles).

BSRTMDL-4: From Indian Creek to Brule Creek (on the South Dakota side), a distance of 42.78 km (26.58 miles).

BSRTMDL-5: From Brule Creek to the Missouri River confluence, a distance of 55.87 km (34.72 miles). This includes two assessment segments.

Since the waterbodies are contiguous the TMDL's for the Big Sioux River were developed jointly but calculated separately. The target for each is the same, an organism count that meets the pathogen indicator water quality standards for Class A designated uses; a geometric mean of 126 *E. coli* organisms/100 ml and a sample maximum of 235 *E. coli* organisms/100 ml.

On the Iowa side of the Big Sioux River, the segment into which each of the HUC 12's discharges and the discharge location are identified in Table 3.3. For calculation purposes it is assumed that there is a single discharge point for all loads from each HUC 12 sub-watershed.

For computational and practical reasons it has been assumed that *E. coli* and fecal coliform monitored and calculated values represent the concentration of organisms throughout the waterbody. Estimated numbers of organisms are diluted in the volume of water in the stream. Based on this, the bacteria delivery from the watershed is the ratio of *E. coli* bacteria indicators available for "washoff" to the number of number of organisms monitored and counted in a given volume of the stream expressed as a percentage.

Table 3.3 Iowa Big Sioux River HUC 12 sub-watershed and Rock River discharge locations and associated assessment segments

model #	HUC 12 Name	BSR discharge location, river km	Iowa assessment segment
25	Big Sioux River	202.00	0010-1
23	Lower Broken Kettle Creek	192.82	0010-1
22	Bull Run	192.82	0010-1
20	Upper Broken Kettle Creek	192.82	0010-1
24	Big Sioux River	176.00	0010-2
21	Westfield Creek	159.61	0010-3
19	Big Sioux River	141.00	0010-3
17	Unnamed Creek-Indian Creek	122.00	0010-3
16	Indian Creek-Dubois Creek	122.00	0010-3
18	Big Sioux River	117.00	0010-4
14	Lower Sixmile Creek	113.42	0010-4
12	Middle Sixmile Creek	113.42	0010-4
11	Upper Sixmile Creek	113.42	0010-4
15	Big Sioux River	108.00	0010-4
10	Dry Creek-Big Sioux River	102.63	0010-4
13	Big Sioux River	95.00	0010-4
RR	**Rock River**	87.69	0010-4
9	Big Sioux River	67.00	0020-1
8	Inwood	35.43	0020-2
7	Big Sioux River	29.00	0020-2
5	Klondike Creek	23.28	0020-2
6	Big Sioux River	16.70	0020-2
4	Big Sioux River	8.00	0020-3
3	Blood Run	6.12	0020-3
1	Big Sioux River	2.00	0020-3
2	Unnamed Creek-Rowena	0.00	0020-3

3.1.6 Potential Pollution Sources

<u>Iowa Point Sources</u>

There are 19 permitted point sources in the Big Sioux River Iowa watershed that are potential sources of pathogen indicators. Most are wastewater treatment plants (wwtp) for small municipalities. Tables 3.5 and 3.6 list the NPDES permitted facilities in the Iowa Rock River watershed and the directly draining part of the Iowa Big Sioux River watershed, respectively. For each facility the tables list the treatment process used, design population equivalent, distance to the Big Sioux River, and whether or not the facility is currently disinfecting its effluent.

Table 3.4 Wastewater treatment plants in the Iowa Rock River watershed

Facility name	Treatment process	Design PE*	Distance to the Big Sioux River, miles	Disinfecting?
Alvord wwtp	Controlled discharge lagoon	269	36.4	No
Ashton wwtp	Controlled discharge lagoon	629	68.5	No
Doon wwtp	Controlled discharge lagoon	454	27.3	No
George wwtp	Controlled discharge lagoon	1257	49.3	No
Hull wwtp	Trickling filter	2994	35.9	No
Lester wwtp	Controlled discharge lagoon	251	45.3	No
Little Rock wwtp	Controlled discharge lagoon	527	68.6	No
Niessink Home	Primary treatment	20	25.6	No
Rock Rapids wwtp	Trickling filter	2934	44.3	No
Rock Valley of wwtp	Aerated lagoon	3174	18.9	No
Sibley wwtp	Aerated lagoon	10922	78.6	No

*population equivalent

Table 3.5 Wastewater treatment plants in the direct Iowa BSR watershed

Facility name	Treatment process	Design PE*	Distance to Big Sioux River, miles	Disinfecting?
Akron, City of wwtp	Controlled discharge lagoon	2216	0	No
Grand Laboratories wwtp	Controlled discharge lagoon	464	5.1	No
Hawarden, City of wwtp	Activated Sludge	21467	0	yes
Inwood, City of wwtp	Aerated lagoon	1006	6.3	No
Ireton, City of wwtp	Trickling filter	754	18.2	No
Larchwood, City of wwtp	Controlled discharge lagoon	675	9.6	No
West Lyon Comm. School	Controlled discharge lagoon	240	8.3	No
Westfield, City of wwtp	Controlled discharge lagoon	234	0	No

*population equivalent

<u>South Dakota Point Sources</u>

Point sources on the South Dakota side of the Big Sioux are the municipal wastewater treatment plants in their part of the watershed. The City of Sioux Falls is the largest of these. There is a difference in the length of the disinfection season for South Dakota and Iowa. The contact recreation season in Iowa is between March 15 and November 15 while in South Dakota it is between April 1 and October 1. This means that from March 15 to April1 and from October 1 to November 15, even South Dakota plants that are currently disinfecting for the South Dakota recreation season are potential sources. The loads from these point sources will be included in the load allocations where flows from the South Dakota part of the watershed enter the Big Sioux River once the South Dakota data is available.

Iowa Nonpoint Sources
The non-point pathogen indicator sources in the Iowa part of the Big Sioux River watershed are livestock, wildlife, and failed onsite septic tank systems. The non-point source (NPS) pollutant source components are livestock and wildlife fecal material that is transported periodically during precipitation events and those that are continuous such as discharges from leaking septic tank treatment systems and manure from cattle in and near streams.

South Dakota Nonpoint Sources
As in Iowa, the non-point pathogen indicator sources in the South Dakota part of the Big Sioux River watershed are livestock, wildlife, and failed onsite septic tank systems. For the purposes of this TMDL it is assumed that pollutants from the South Dakota non-point sources are the South Dakota tributary streams and the Big Sioux River itself where they flow into the five impaired segments. The various point and non-point sources within South Dakota are not specifically identified.

Minnesota Point and Non-point Sources
For the purposes of this TMDL it is assumed that sources originating in Minnesota are the waterways themselves and specific point and non-point sources are not identified. There are two sources of pollutants from the parts of the larger Big Sioux River watershed that originate in Minnesota. One of these is the part of the Rock River watershed that is north of the border. There are three major tributaries from the Minnesota Rock River watershed: Mud Creek, the Rock River, and the Little Rock River. The second source is from the Big Sioux River itself as it crosses the Iowa/Minnesota border into the BSRTMDL-1 segment that runs from the border to Indian Creek.

3.1.7 Natural Background Conditions
Natural background conditions are assumed to be the *E. coli* load associated with wildlife. This loading has been included in the non-point source load from the watershed.

3.2 TMDL Target
The target for each of the five Big Sioux River TMDLs is the water quality standard for Class A1, Primary Contact Recreational Use which is a geometric mean of 126 *E. coli* orgs./100ml and a single sample maximum of 235 *E. coli* orgs/100ml. The "load" associated with this concentration varies with flow conditions.

3.2.1 Criteria for Assessing Water Quality Standards Attainment
The criteria used to determine attainment of the water quality standards is explained in the 305b report assessment protocol described in the preceding *Section 3.1, Problem Identification*.

3.2.2 Selection of Environmental Conditions

There are two ways that are used to describe flow conditions in this report. The first method is stratification or lumping of measured flow into high and low flow categories. In general, the high flow data are from event automatic samplers and the low flow and very low flow data are from samples taken at regular intervals, usually monthly. The second way is to organize the flow by percent occurrence in flow duration and load duration curves. Both of these methods are described in Appendix B, Procedures and Assumptions.

High Flow: High flow carries the pollutants in the watershed that are transported during rainfall events. In the Big Sioux River watershed this includes the fecal material available for wash-off from livestock and wildlife. The pollutant loads monitored during high flow are assumed to be associated with this condition. The data indicate that high flows are accompanied by very high *E. coli* counts. The combination of high flow and high concentrations mean that total *E. coli* counts are very elevated compared to low flow periods.

Low and Very Low Flow: These flow conditions occur when there is little or no runoff occurring and the stream flow consists mostly of groundwater and continuous discharges from sources like wastewater treatment plants, failed septic systems, and cattle in streams. During periods of low flow, relatively small numbers of fecal coliform can cause water quality standard violations. Design of wastewater treatment plant discharge permits is based on defined low flow conditions, usually the 7-day average low flow with a 10-year recurrence (7Q10).

3.3 Linkage of Sources and Targets: Load Representation, Transportation, and Fate Procedures

Several analytical tools have been used to estimate loads from point and non-point sources, to link the sources to the impaired waterbodies, and to evaluate the impact of the source loads on the ability of a Big Sioux River segment to meet the water quality criteria. Appendix A: E-file Index lists the data, data analysis, modeling, and allocation and ArcView GIS procedures available in digital format. Appendix B: Procedures and Assumptions describes the key spreadsheets and assumptions of TMDL development.

Geographical Information System and IDNR Data Coverages: IDNR maintains databases and ArcView GIS coverages of landuse, livestock numbers and distribution, locations of wastewater treatment facilities, various hydrologic units, stream locations, recent infrared photography with one meter resolution, USGS 7.5 minute contour maps, etc. These tools were used to estimate stream length and width, locations of pollutant load inputs, changes in stream slope, distribution of rural population on failed septic systems, and wildlife numbers and distribution. Coverages and maps used to develop the Big Sioux River TMDLs can be found in the ArcView GIS E-folder. An index of this folder can be found in Appendix A.

Livestock Census and Distribution Estimates: Livestock have been estimated using the Confined Animal Feeding Operation (CAFO) databases, county livestock census data, land uses and GIS aerial infrared photography. Data from these sources has been evaluated and livestock numbers for each 12 digit hydrologic unit have been estimated and used as input for the modified EPA Bacteria Indicator Tool described below. The Iowa portions of the Rock River watershed and the direct draining Big Sioux River watershed HUC 12's have been evaluated separately. There are 23 HUC 12's in the Rock River watershed that have been evaluated and that discharge through the Rock River to the BSRTMDL-3 segment that runs from the Rock River to Indian Creek. There are 25 HUC 12's that discharge directly to the Big Sioux or to a stream that discharges directly to the Big Sioux River.

Modified EPA Bacteria Indicator Tool: The Bacteria Indicator Tool (BIT) is a spreadsheet that was developed by the EPA to provide input for the Hydrological Simulation Program FORTRAN (HSPF). HSPF has not been used to develop these TMDLs but the spreadsheet has been restructured and modified by IDNR to provide daily fecal coliform loads available for wash-off during precipitation events in pasture and cropland from livestock, and in forest, cropland and pasture from wildlife sources, measured as total organism counts. The tool estimates the monthly accumulation rate and uses estimated asymptotic limits of 1.5 (summer) and 1.8 (spring and fall) times the maximum daily accumulation if no wash-off occurs. The input and output are based on monthly assumptions about manure applications and grazing practices. Fecal coliform loads are translated to E. coli values as final worksheet calculations prior to being entered into the TMDL document tables as discussed in Appendix B Procedures and Assumptions.

The modified BIT also estimates continuous and direct inputs from cattle in streams and failed septic tanks. Assumptions about when and how many cattle are direct stream inputs vary by the month of the year. It is assumed that the failed onsite septic systems are a direct and continuous input to the stream. The number of failed septic systems was estimated from the population that does not reside in towns with municipal treatment and the 2002 census block data clipped by HUC 12 using GIS methods.

The rationale for most of the assumptions and procedures used in the BIT are explained in Appendix B Procedures and Assumptions and are embedded in the relevant spreadsheets. Additional development information and calculations can be found in the electronic files listed in Appendix A.

Load Duration Curves: Load duration curves are being used in this report to compare monitored bacteria concentrations and flow data to the water quality standard values at the range of flow conditions. The flow is represented as a percentage of the time a flow rate occurs. The lower the percentile rank, the higher the flow. The highest percentile ranks are for the lowest flows.

Monitoring data that exceeds the water quality standard values at high flow (low percentage) indicates sources that are problems during precipitation events when pollutants available for wash off in the watershed are transported to the stream in runoff. Violations at low flow are from direct and continuous discharges. Examples of runoff driven sources are manure applied to crop and pasture lands, built-up urban areas, and areas inhabited by large numbers of wildlife. Examples of direct and continuous discharges are wastewater treatment plants, cattle in streams, and failed septic systems. Investigating duration curve hydrological conditions can often separate point and non-point sources and their impacts.

<u>Pollutant Fate: Estimating Stream Velocity and Pathogen Die-off</u>: The fate of pathogen indicators from the sources to the particular HUC 12 discharge locations to the discharge locations on the particular impaired Big Sioux River segment have been evaluated using estimated time of travel and a bacteria indicator die off factor. To get the time of travel, the velocity was estimated using the Manning's equation; stream length was estimated by digitizing GIS measurements from aerial photography (one meter resolution). The slope for use in Manning's equation was estimated by measuring the distance between the contours crossing the streams on USGS 7.5 minute topo maps that are available in the Iowa GIS system, and then assuming a linear relationship of the vertical fall to the horizontal distance. Cross-sectional area was estimated using measured width, monitored flow, and field data. Roughness was taken from tables of typical values for natural streams. The critical design flow conditions used in time of travel estimates were those determined from flow and load duration curves.

3.4 Existing Loads on the Big Sioux River

The existing loads on the Big Sioux River have been evaluated at the Akron, Iowa USGS gage station using monitoring data from the SDDENR targeted TMDL monitoring done in 2002, 2003, and 2004. The daily flows from the USGS gage have been matched with the monitored E. coli concentrations (translated from fecal coliform values, see Appendix B) and plotted on a load duration curve. The USGS flow data from 1980 to 2004 was used to make the flow duration curve that generated the load duration curve. The target curves are for the Water Quality Standard targets of 126 E. coli organisms per 100 milliliters for the geometric mean and a sample maximum of 235 E. coli organisms per 100 milliliters converted to daily loads.

Figure 4 shows the monitored data plotted against the target loading curves. The data on the load duration curve represents the existing overall Lower Big Sioux River condition. This is further developed in subsequent sections for the specific TMDLs. As can be seen, the values that exceed the two target curves occur throughout the flow range. Whether or not the concentration exceeds the target at the two ends, the very high and low flow conditions, is not clear since no samples were collected for these flow conditions. This is due to the fact that flow data was measured daily for 25 years, while the water quality samples were taken much less frequently and for only three years. This means that the more extreme conditions that would be encountered in the longer flow measurement period are less likely to occur during a relatively shorter monitoring period. The first section in Appendix B, Procedures and Assumptions called ‘Ecoli and Fecal Coliform Pathogen Indicator Bacteria’ describes the issues and treatment of the pathogen indicator bacteria used in the development of this load duration curve and throughout the development of this TMDL report.

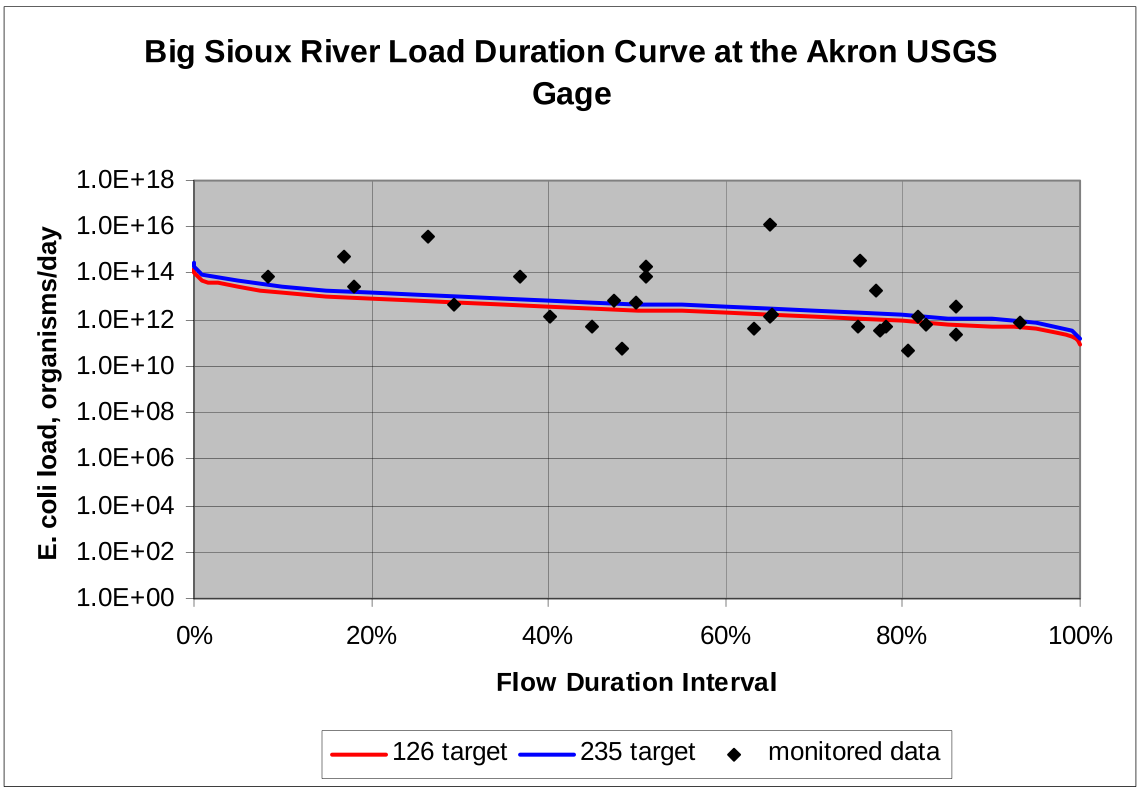

Figure 4 Big Sioux River Load Duration Curve at the Akron USGS gage

3.5 BSRTMDL-1: The Big Sioux River from the Iowa/Minnesota Border to Beaver Creek

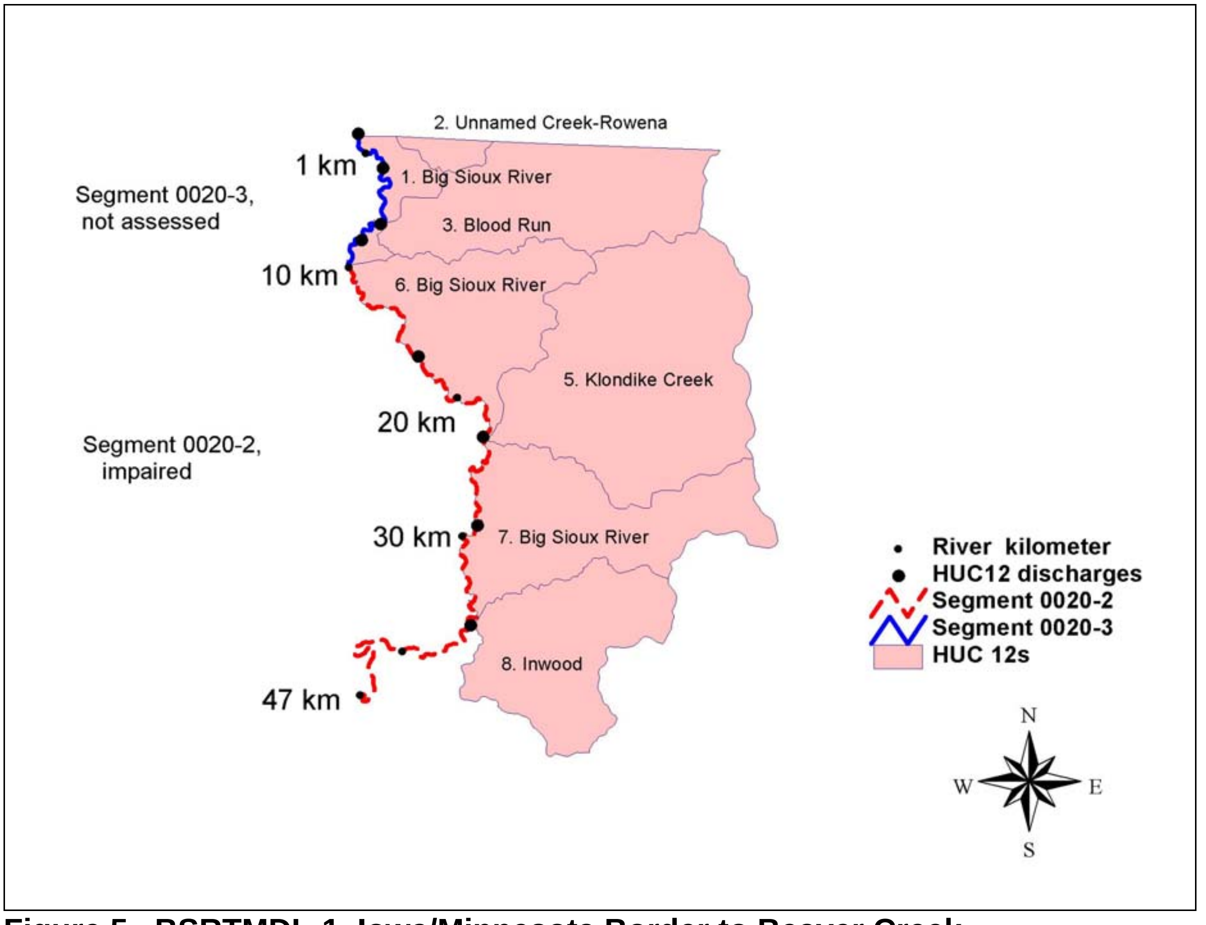

Figure 5. BSRTMDL-1, Iowa/Minnesota Border to Beaver Creek

3.5.1 Pollution Source Assessment

The BSRTMDL-1 segment is 29.2 miles long and drains eight HUC 12's in the Big Sioux River Iowa watershed as shown in Figure 5. The drainage area is 76,690 acres and there are four wastewater treatment plants in the segment's sub-watershed.

Existing Load

The existing load for this segment will be evaluated for the critical flow conditions identified by the load duration curve analysis of monitoring data. At high flow (1% rank) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.6 when the data becomes available.

Table 3.6 BSRTMDL-1, High Flow (1% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	High flow median load *	Sample maximum load*
Brandon, SD	LBSM01, ambient site	River km (-)9	Not available**	Not available**
Klondike Cr., IA	LBSM03	River km 22	Not available**	Not available**
Hwy 18, Canton, SD	Ambient site, no TMDL #	River km 35	Not available**	Not available**
Beloit, IA	LBSM05	River km 45	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

At low flow (70% rank) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.7 when the data becomes available.

Table 3.7 BSRTMDL-1, Low Flow (70% rank): Existing Loads

Monitoring site location	SDDENR site no.	Location	Low flow median load *	Sample maximum load *
Brandon, SD	LBSM01, ambient site	River km (-)9	Not available**	Not available**
Klondike Cr., IA	LBSM03	River km 22	Not available**	Not available**
Hwy 18, Canton, SD	Ambient site, no TMDL #	River km 35	Not available**	Not available**
Beloit, IA	LBSM05	River km 45	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum of concentration of 235 *E. coli* organisms/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Tables 3.8 and 3.9 show the maximum differences measured in both high (1% rank) and low flow (70%) conditions.

Table 3.8 BSRTMDL-1, High Flow (1% rank), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load*	Maximum allowable load *	% reduction required
Brandon, SD	LBSM01, ambient site	Not available**	Not available**	Not available**
Klondike Cr., IA	LBSM03	Not available**	Not available**	Not available**
Hwy 18, Canton, SD	Ambient site, no TMDL #	Not available**	Not available**	Not available**
Beloit, IA	LBSM05	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Table 3.9 BSRTMDL-1, Low Flow (70% rank), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Brandon, SD	LBSM01, ambient site	Not available**	Not available**	Not available**
Klondike Cr., IA	LBSM03	Not available**	Not available**	Not available**
Hwy 18, Canton, SD	Ambient site, no TMDL #	Not available**	Not available**	Not available**
Beloit, IA	LBSM05	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-1 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. Each feedlot in the South Dakota watershed was identified and evaluated. This information will eventually be included by SDDENR in a watershed model called Annualized AgNPS (Agriculture NPS) for the South Dakota Big Sioux watershed. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

<u>Iowa Pollutant Sources</u>:
The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from South Dakota and Minnesota, loads from four wastewater treatment plants, and non-point sources discharging from this segment's eight HUC 12 sub-watersheds.

Iowa Point Sources: There are four wastewater treatment plants in the BSRTMDL-1 watershed. The distance of each of these from the Big Sioux River has been measured and the delivered load calculated using time of travel and an assumed bacteria die-off coefficient of 0.96 per day during low flow conditions when continuous sources have their greatest impact. Appendix B, Procedures and Assumptions explains the evaluation spreadsheets and the assumptions, modeling equations, and rationale for plant treatment reductions. Table 3.10 table shows the delivered loads assuming no effluent disinfection.

Table 3.10 BSRTMDL-1, Wastewater treatment plant *E. coli* loads at BSR

NAME	distance to BSR, km	Low flow time of travel, days	WWTP effluent load *	Load at the BSR *
Grand Lab wwtp	8.12	0.43	5.85E+10	3.87E+10
Inwood wwtp	10.16	0.71	1.04E+11	5.25E+10
Larchwood wwtp	15.40	0.95	9.31E+10	3.73E+10
West Lyon School wwtp	13.34	0.71	3.02E+10	1.53E+10

*Units for these loads are *E. coli* organisms/day.

Three of these facilities are controlled discharge lagoons and one is a continuous discharge aerated lagoon. Table 3.5 includes a summary of plant characteristics. In general, controlled discharge lagoons are designed to discharge infrequently, perhaps twice a year, for two or three weeks during higher stream flows. Discharges are usually in the spring and fall.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.12 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.11 to 3.13 show the delivered loads for the various non-point sources for the eight HUC 12's on the Iowa side that discharge into the BSRTMDL-1 segment.

Table 3.11 BSRTMDL-1, Livestock, wildlife and built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR **	June load * at BSR **	Oct. load * at BSR **
1	Big Sioux River	0.00	6.10E+11	4.69E+11	3.83E+12
2	Unnamed Cr. Rowena	0.00	1.09E+09	1.09E+09	1.30E+09
3	Blood Run	0.00	3.39E+13	2.46E+13	2.19E+14
4	Big Sioux River	0.00	3.79E+08	3.79E+08	4.48E+08
5	Klondike Creek	0.00	6.35E+13	4.51E+13	4.10E+14
6	Big Sioux River	0.00	3.45E+13	2.62E+13	2.25E+14
7	Big Sioux River	0.00	1.58E+13	1.11E+13	1.01E+14
8	Inwood	0.00	7.98E+13	5.90E+13	5.18E+14

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.12 BSRTMDL-1, Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
1	Big Sioux River	3	0	2.35E+10	4.70E+10	2.35E+10
2	Unnamed Cr-Rowena	0	0	0.00E+00	0.00E+00	0.00E+00
3	Blood Run	119	0	9.26E+11	1.85E+12	9.26E+11
4	Big Sioux River	0	0	0.00E+00	0.00E+00	0.00E+00
5	Klondike Creek	203	0	1.58E+12	3.16E+12	1.58E+12
6	Big Sioux River	128	0	9.96E+11	1.99E+12	9.96E+11
7	Big Sioux River	53	0	4.14E+11	8.29E+11	4.14E+11
8	Inwood	283	0	2.20E+12	4.41E+12	2.20E+12

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle that are assumed to be in the stream.

Table 3.13 BSRTMDL-1, Failing Septic systems NPS loads

No.	HUC 12 name	No. of failed septics	Distance to BSR, km	Load at BSR *
1	Big Sioux River	14	0.00	6.15E+08
2	Unnamed Cr.-Rowena	8	0.00	3.75E+08
3	Blood Run	111	0.00	4.94E+09
4	Big Sioux River	4	0.00	1.73E+08
5	Klondike Creek	194	0.00	8.63E+09
6	Big Sioux River	90	0.00	4.01E+09
7	Big Sioux River	111	0.00	4.95E+09
8	Inwood	95	0.00	4.22E+09

*Units for these loads are *E. coli* organisms/day.

<u>South Dakota Pollutant Sources</u>

The South Dakota pollutant sources for this segment consist of the loads from the upstream Big Sioux River component as measured at Brandon, the load from the Lake Alvin outlet measured at the BSR confluence, and the direct HUC 12 loads.

Estimates of these loads will be made by SDDENR and will be reported in Table 3.14 as they become available.

Table 3.14 BSRTMDL-1, South Dakota Pollutant Load Estimates

Pollutant Source	Location	SDDENR site no.	High flow (1%) load *	Low flow (70%)load *
Big Sioux River upstream	Model km 0	LBSM01	Not available**	Not available**
Lake Alvin Outlet	Model km 10	LBST02	Not available**	Not available**
Direct HUC 12's	Incremental***	NA	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.
***Loads to the BSR from adjoining HUC 12's are incrementally distributed along the BSR length as bacteria load per km.

3.5.2 Pollutant Allocations

Wasteload Allocations

Wastewater Treatment Plant Wasteload Allocations: The wasteload allocations (WLA) for the Iowa wastewater treatment plants in the BSRTMDL-1 segment sub-watershed are based on the standard assumption that effluent concentration must meet the water quality standard at the point where it enters a stream that has the Class A1 Primary Contact Recreational Use designation. Therefore, the WLA for a plant discharging directly into a classified stream would be the same as the numeric *E. coli* water quality standard. The wastewater treatment plant *E. coli* loads delivered to the BSRTMDL-1 segment and the distance of the plant discharge from the BSR is shown in Table 3.10 in Section 3.5.1 Pollution Source Assessment.

Wasteload allocations for discharges some distance from the designated use waterbody (BSR) are calculated using the estimated time of travel between the discharge location and the Big Sioux River and a bacteria die-off factor. The time of travel estimates for the four BSRTMDL-1 wastewater treatment plants used time of travel calculations for segments of Mud Creek similar to the streams receiving the plant effluent. (See the spreadsheets *Mud Time of Travel.xls* and *BSR direct wwtp.xls* listed in Appendix A.) The Mud Creek time of travel estimates were calculated from flow monitoring data stratified into three categories; high flow, low flow, and very low flow.

Wasteload allocations were calculated for the most stringent condition, which is low flow. At high flow, the load from these small facilities is not over the E. coli standard and is also dwarfed by the surface run-off loads. At very low flow, the reduced stream velocity allows for greater die-off so the allocation concentration at the discharge location is higher (less stringent) than for low flow.

For the indirect discharges, the time of travel has been estimated at low flow and die-off has been back calculated from the Big Sioux River upstream to the discharge location. The calculations and assumptions used in the development of wasteload allocations are in the time of travel and bacteria die-off sections of Appendix B, Procedures and Assumptions.

These WLA's apply from March 15 through November 15 and are intended to provide *E. coli* and fecal coliform concentrations at the confluence with the Big Sioux River that complies with the *E. coli* Water Quality Standards (WQS). The WQS values for *E. coli* are a geometric mean of 126-organisms/100 ml and a sample maximum of 235-organisms/100 ml. The WLA's for the BSRTMDL-1 wastewater treatment plants are in Table 3.15.

Table 3.15 BSRTMDL-1 Iowa WWTP Wasteload Allocations

Name	**WQS load at BSR, *E. coli* org/day ***	**WLA at wwtp location, *E. coli* org./day ****	**WLA geometric mean, *E. coli* org/100 ml *****	**WLA sample max. *E. coli* org/100 ml *****
Grand Lab wwtp	7.39E+08	1.12E+09	**191**	**356**
Inwood wwtp	1.57E+09	3.11E+09	**249**	**466**
Larchwood wwtp	3.77E+08	9.40E+08	**314**	**588**
West Lyon School wwtp.	1.14E+09	2.26E+09	**249**	**466**

*This is the allowable total daily load for the wwtp in *E. coli* organisms per day for the design plant flow at the WQS concentration of 126 E. coli organisms/100ml.
**This is the allowable total daily load at the effluent discharge location after die-off has been calculated at low flow time of travel.
***Concentration WLA's are based on the E. coli numeric WQS values of 126-organisms/100 ml for geometric mean and 235-organisms/100 ml for the sample maximum and accounting for die-off between the discharge and the BSR. Standard applies from March 15 to November 15.

<u>BSR Direct Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations</u>: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There is one NPDES permitted animal feeding operation facility in the BSR direct watershed that drains to the BSRTMDL-1 impaired segment. The wasteload allocation for this facility follows state (IAC 567- Ch.65) and federal rules (40 CFR 125.30 through 125.32) requirements for open feedlots. The relevant state rule, IAC 567 – 65.101(2)a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facility, its location, HUC 12, and WLA, is shown in Table 3.16.

Table 3.16 BSRTMDL-1 BSR Direct Watershed NPDES Permitted Animal Feeding Operation Facility Wasteload Allocation

Facility Name	Facility ID	NPDES permit #	EPA #	Township and range	Sec	1/4 Sec	HUC 12	WLA
Hoogendoorn Feedlot	56506	60-00-0-07	IA0079502	T98N R48W	35	SE	BSR #8*	No discharge**

*This refers to the HUC 12 sub-watershed in the BSR direct watershed and corresponds to the HUC 12 number in column one of Table 3.17.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocations and Pollutant Load Reductions Needed
The load allocations for this TMDL are based on the discharges from the eight Iowa HUC 12s that discharge to the BSRTMDL-1 segment and the loads from the South Dakota hydrologic units, tributary streams, and the Big Sioux River itself where it crosses into Iowa. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves (spreadsheet *stream data analysis.xls*) for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.17 through 3.20). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.17 BSRTMDL-1 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation*	Existing Load *	Reduction needed
1	Big Sioux River	3.14E+10	5.16E+11	93.9%
2	Unnamed Cr.-Rowena	1.91E+10	1.47E+09	none
3	Blood Run	2.52E+11	2.65E+13	99.0%
4	Big Sioux River	8.80E+09	5.52E+08	none
5	Klondike Creek	4.40E+11	4.83E+13	99.1%
6	Big Sioux River	2.05E+11	2.82E+13	99.3%
7	Big Sioux River	2.53E+11	1.19E+13	97.9%
8	Inwood	2.15E+11	6.34E+13	99.7%

*Units for these loads are *E. coli* organisms/day.

Table 3.18 BSRTMDL-1 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Big Sioux River	6.35E+09	6.10E+10	89.6%
2	Unnamed Cr.-Rowena	3.87E+09	4.06E+08	none
3	Blood Run	5.10E+10	2.56E+12	98.0%
4	Big Sioux River	1.78E+09	1.83E+08	none
5	Klondike Creek	8.92E+10	4.46E+12	98.0%
6	Big Sioux River	4.14E+10	2.75E+12	98.5%
7	Big Sioux River	5.12E+10	1.15E+12	95.6%
8	Inwood	4.36E+10	6.10E+12	99.3%

*Units for these loads are *E. coli* organisms/day.

Table 3.19 BSRTMDL-1 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Big Sioux River	2.38E+09	4.89E+10	95.1%
2	Unnamed Cr.-Rowena	1.45E+09	3.78E+08	none
3	Blood Run	1.91E+10	1.93E+12	99.0%
4	Big Sioux River	6.68E+08	1.74E+08	none
5	Klondike Creek	3.34E+10	3.30E+12	99.0%
6	Big Sioux River	1.55E+10	2.07E+12	99.3%
7	Big Sioux River	1.92E+10	8.66E+11	97.8%
8	Inwood	1.63E+10	4.58E+12	99.6%

*Units for these loads are *E. coli* organisms/day.

Table 3.20 BSRTMDL-1 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Big Sioux River	1.59E+09	4.77E+10	96.7%
2	Unnamed Cr.-Rowena	9.68E+08	3.75E+08	none
3	Blood Run	1.27E+10	1.86E+12	99.3%
4	Big Sioux River	4.46E+08	1.73E+08	none
5	Klondike Creek	2.23E+10	3.19E+12	99.3%
6	Big Sioux River	1.04E+10	2.00E+12	99.5%
7	Big Sioux River	1.28E+10	8.37E+11	98.5%
8	Inwood	1.09E+10	4.43E+12	99.8%

*Units for these loads are *E. coli* organisms/day.

3.6 BSRTMDL-2: The Big Sioux River from Beaver Creek to the Rock River.

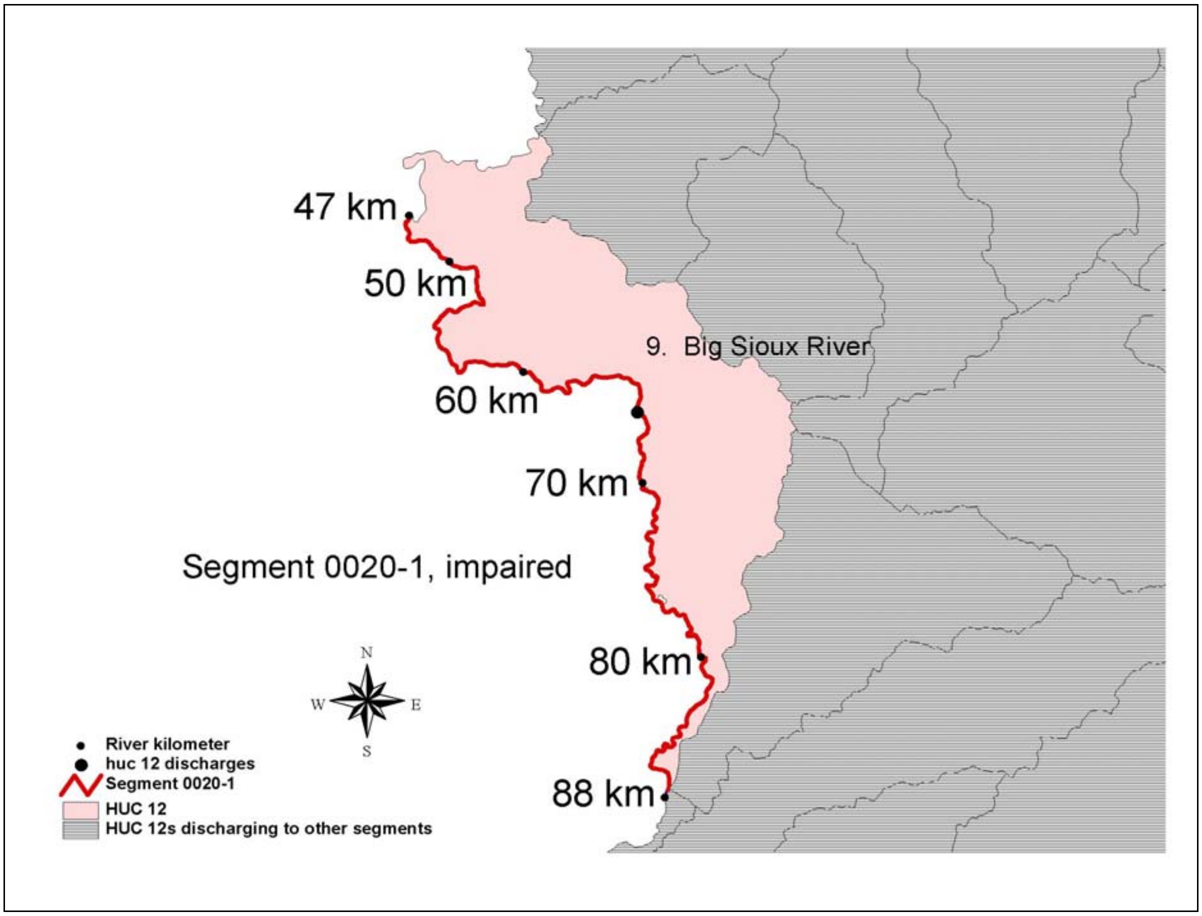

Figure 6. BSRTMDL-2, Beaver Creek to the Rock River

3.6.1 Pollution Source Assessment

The BSRTMDL-2 segment is 25.3 miles long but drains only one of the 48 HUC 12's in the Big Sioux River Iowa watershed as shown is Figure 6. The drainage area is 26,670 acres and there are not any wastewater treatment plants in the segment's sub-watershed.

Existing Load

The existing load for this segment will be evaluated for the critical flow conditions identified by the load duration curve analysis of monitoring data. At high flow (1% rank) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.21 when it is available.

Table 3.21 BSRTMDL-2 High Flow (1% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	High flow median load *	Sample maximum load *
Fairview, IA	LBSM08	River km 65	Not available**	Not available**
Hudson, SD	LBSM09, ambient site	River km 79	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

At low flow (70% rank) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.22 when it becomes available.

Table 3.22 BSRTMDL-2 Low Flow (70% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	Low flow median load*	Sample maximum load*
Fairview, IA	LBSM08	River km 65	Not available**	Not available**
Hudson, SD	LBSM09, ambient site	River km 79	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum of 235 *E. coli* organisms/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Tables 3.23 and 3.24 show the maximum differences measured in both high (1% rank) and low flow (70% rank) conditions.

Table 3.23 BSRTMDL-2 High Flow (1% rank), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Fairview, IA	LBSM08	Not available**	Not available**	Not available**
Hudson, SD	LBSM09, ambient site	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Table 3.24 BSRTMDL-2 Low Flow (70% rank), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Fairview, IA	LBSM08	Not available**	Not available**	Not available**
Hudson, SD	LBSM09, ambient site	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-2 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. Each feedlot in the South Dakota watershed was identified and evaluated. This information will eventually be included by SDDENR in a watershed model called Annualized AgNPS (Agriculture NPS) for the South Dakota Big Sioux watershed. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

<u>Iowa Pollutant Sources:</u>

The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from BSRTMDL-1, and non-point sources from the one HUC 12 that drains directly to this river segment.

Iowa Point Sources: There are not any permitted wastewater treatment plants and there are three permitted Animal feeding operations in the BSRTMDL-2 sub-watershed.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.26 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.25 to 3.27 show the delivered loads for the various non-point sources for the one HUC 12 on the Iowa side that discharges into the BSRTMDL-2 segment.

Table 3.25 BSRTMDL-2, Livestock, wildlife, built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR **	June load* at BSR **	Oct. load * at BSR**
9	Big Sioux River	0.0	3.62E+14	2.72E+14	2.42E+15

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.26 BSRTMDL-2, Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams, *
9	Big Sioux River	974	0.0	7.60E+12	1.52E+13	7.60E+12

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle assumed to be in the stream.

Table 3.27 BSRTMDL-2, Failing Septic systems NPS loads

No.	HUC 12 name	No. of Failed septics	distance to BSR, km	load at BSR *
9	Big Sioux River	218	0.0	9.71E+09

*Units for these loads are *E. coli* organisms/day.

<u>South Dakota Pollutant Sources</u>
The South Dakota pollutant sources for this segment consist of the loads measured at Beaver Creek, at Lower Beaver Creek and at Pattee Creek near their confluences with the Big Sioux River, and the direct HUC 12 loads. Estimates of these loads will be made by SDDENR and will be put in Table 3.28 when they are available.

Table 3.28 BSRTMDL-2, South Dakota Pollutant Load Estimates

Pollutant Source	**Location**	**SDDENR site no.**	**High flow (1%) load ***	**Low flow (70%) load ***
Beaver Cr. S of Canton	River km 47	LBST06	Not available**	Not available**
Little Beaver Cr.	River km 48	LBST07	Not available**	Not available**
Pattee Cr.	River km 86	LBST10	Not available**	Not available**
Direct HUC 12's	Incremental***	NA	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.
***Loads to the BSR from adjoining HUC 12's are incrementally distributed along the BSR length by bacteria load per km.

3.6.2 Pollutant Allocations

Wasteload Allocation

Wastewater Treatment Plant Wasteload Allocations: There are no wastewater treatment plants in the BSRTMDL-2 sub-watershed on the Iowa side of the Big Sioux River. Therefore, there are no wwtp wasteload allocations for this TMDL.

BSR Direct Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There are three NPDES permitted animal feeding operation facilities in the BSR direct watershed that drain to the BSRTMDL-2 impaired segment. The wasteload allocation for these facilities follows state (IAC 567- Ch.65) and federal rules (40 CFR 125.30 through 125.32) for open feedlots. The relevant state rule, IAC 567 – 65.101(2)a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facilities, their locations and HUC 12, and WLA's are shown in Table 3.29.

Table 3.29 BSRTMDL-2 BSR Direct Watershed NPDES Permitted Animal Feeding Operation Facilities Wasteload Allocations

Facility Name	Facility ID	NPDES #	EPA #	Township and range	Sec	1/4 Sec	HUC 12 *	WLA **
Ysseltein Dairy, Inc. North	62015	84-00-3-02	77844	T97N R47W	18	SE	BSR #9	No discharge
Ysseltein Dairy, Inc. South	61393	84-00-3-11	77852	T97N R47W	19	SW	BSR #9	No discharge
Bar K Farms- Inwood	56567	84-00-0-32	77518	T97N R48W	4	NE	BSR #9	No discharge

*This refers to the HUC 12 sub-watershed in the BSR direct watershed and corresponds to the HUC 12 number in column one of Table 3.17.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocations and Pollutant Load Reductions Needed

The load allocations for this TMDL are based on the discharges from the one Iowa HUC 12 that discharges to the BSRTMDL-2 segment, the loads from the South Dakota hydrologic units, tributary streams, and the BSRTMDL-1 segment of the Big Sioux River where it flows into the BSRTMDL-2 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the water quality standard sample maximum criteria of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves (spreadsheet *stream data analysis.xls*) for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.30 through 3.33). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.30 BSRTMDL-2 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	4.95E+11	2.87E+14	99.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.31 BSRTMDL-2 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	1.00E+11	2.30E+13	99.6%

*Units for these loads are *E. coli* organisms/day.

Table 3.32 BSRTMDL-2 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	3.76E+10	1.60E+13	99.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.33 BSRTMDL-2 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	2.51E+10	1.53E+13	99.8%

*Units for these loads are *E. coli* organisms/day.

3.7 BSRTMDL-3: The Big Sioux River from the Rock River to Indian Creek.

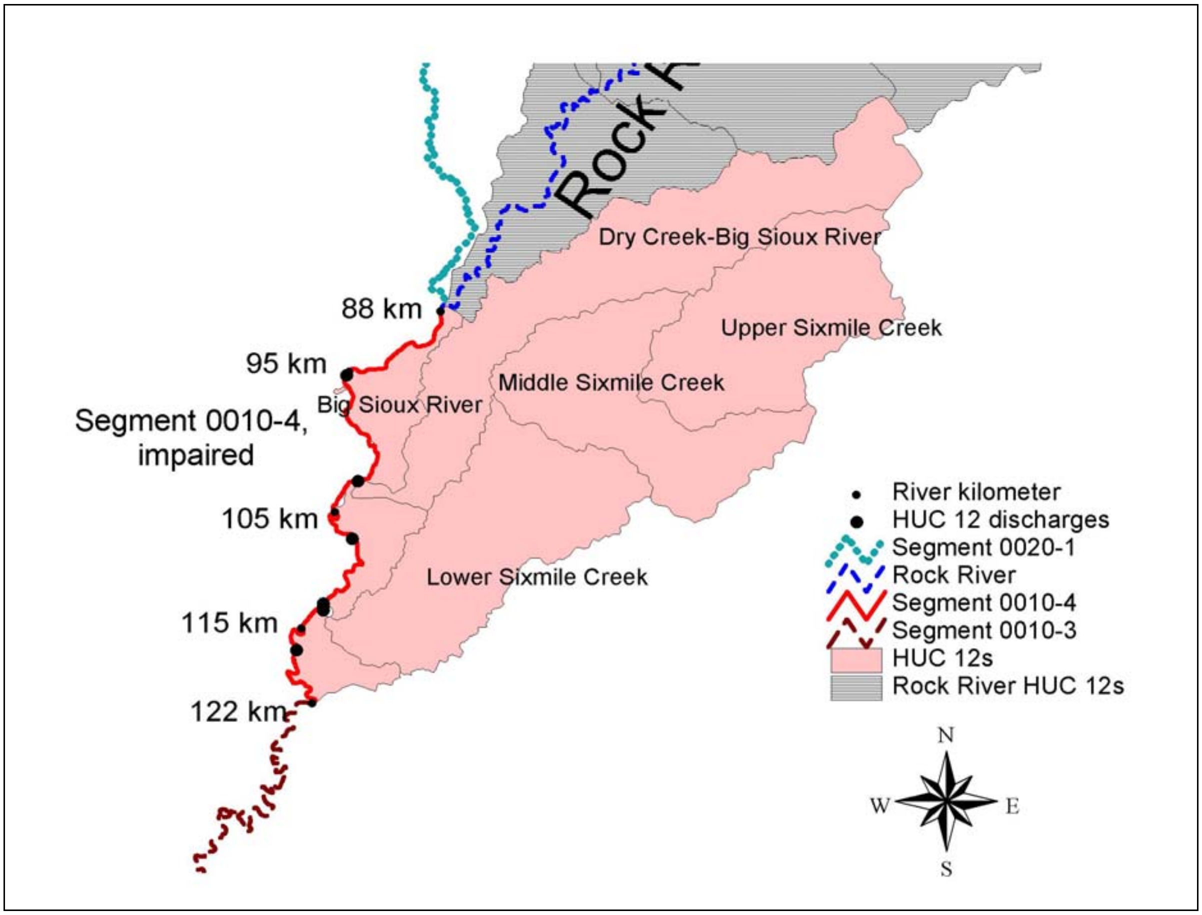

Figure 7. BSRTMDL-3, Rock River to Indian Creek

BSRTMDL-3 Organization. The BSRTMDL-3 segment watershed includes Iowa and Minnesota parts of the Rock River watershed as well as seven HUC 12's that drain directly to the Big Sioux River as shown in Figures 7 and 8. The first part of BSRTMDL-3 is an evaluation of the Rock River *E. coli* point and non-point sources and loads from both Iowa and Minnesota. The second part is an evaluation of the existing *E. coli* loads in the BSRTMDL-3 segment and an estimate of the departure from load capacity and an evaluation of the *E. coli* point and non-point sources and loads from the seven directly draining HUC 12's. The last part includes the wasteload allocations and reductions from the Rock River watershed and the load allocations from the Rock River watershed, including the Minnesota load allocations, and the load allocations and reductions from the seven directly draining HUC 12's.

3.7.1 Pollution Source Assessment - Rock River watershed

The Iowa part of the Rock River includes 23 HUC 12 sub-watersheds. As noted in the section on Data Sources, data was collected in 2002 and 2003 for the Rock River at the Hawarden ambient site, at the Rock Valley gage, at the confluence of Mud Creek and the Rock River, at the confluence of the Little Rock and Rock Rivers, at the USGS gage site downstream of Rock Rapids, and where Mud Creek, the Rock River, and the Little Rock River cross into Iowa from Minnesota. The 23 HUC 12 sub-watersheds that comprise the Iowa part of the Rock River watershed were evaluated separately from the 25 HUC 12 sub-watersheds that drain directly into the Big Sioux River.

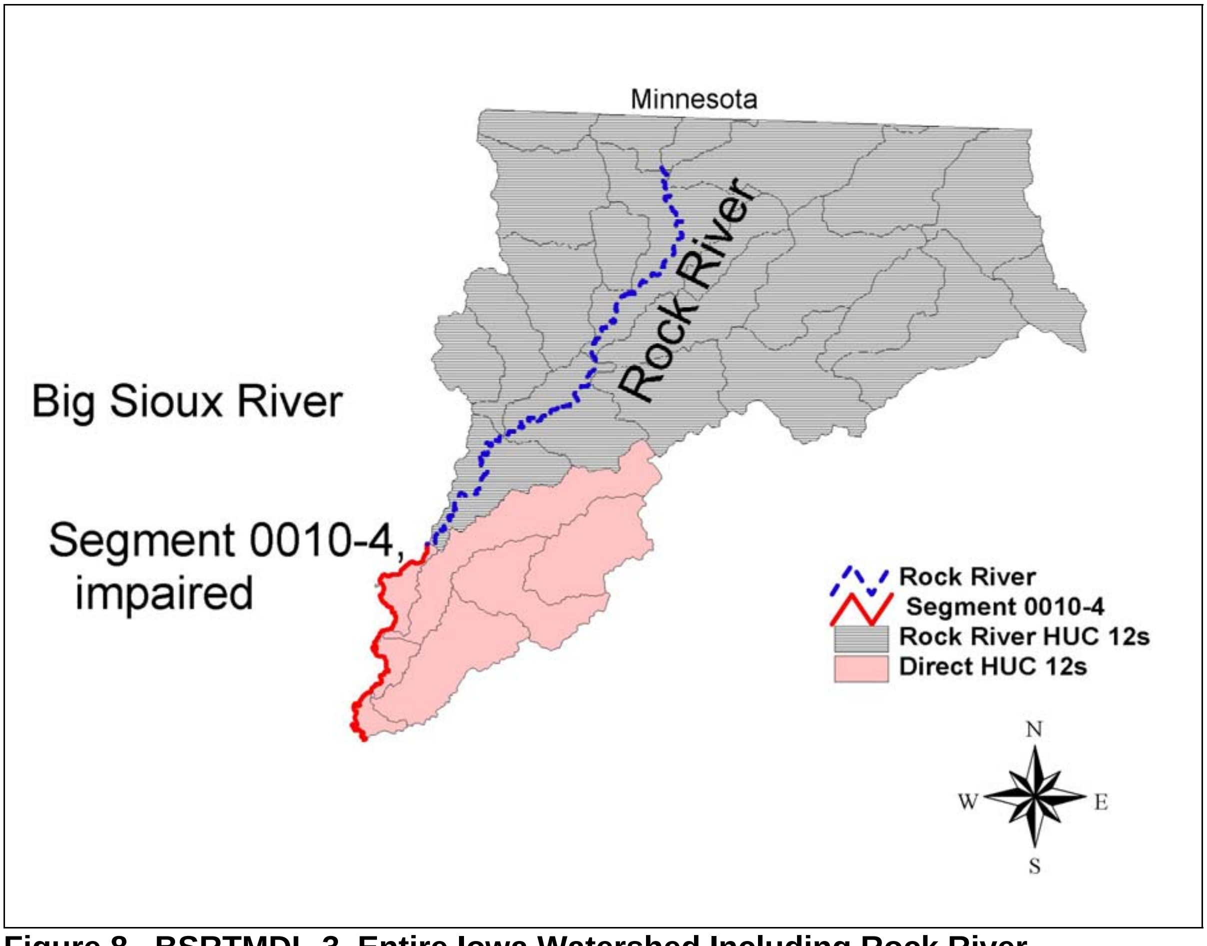

Figure 8. BSRTMDL-3, Entire Iowa Watershed Including Rock River

Rock River, Identification of Pollutant Sources

The pollutant sources for the Rock River watershed are located in both Iowa and Minnesota. The Iowa and Minnesota loads are considered together as loads delivered at the Big Sioux River confluence. The Minnesota loads have been estimated based on the monthly monitoring data at the Mud Creek, Rock River, and Little Rock River sites where they cross the border.

Iowa Pollutant Sources:
The pollutant sources in the Iowa part of the Rock River watershed consist of point source loads from eleven wastewater treatment plants and non-point sources discharging from the 23 Rock River HUC 12's.

Iowa Point Sources: There are eleven wastewater treatment plants in the BSRTMDL-3 Iowa Rock River watershed. The distance of each of these from the Rock River and the Big Sioux River has been measured and the delivered load calculated using time of travel and an assumed bacteria die-off coefficient of 0.96 per day during low flow conditions when continuous sources have their greatest impact. Appendix B, Procedures and Assumptions explains the evaluation spreadsheets and the assumptions, modeling equations, and rationale for plant treatment reductions. Table 3.34 shows the delivered loads assuming no effluent disinfection.

Table 3.34 BSRTMDL-3 Rock River Wastewater treatment plant *E. coli* loads at BSR confluence

NAME	Distance to BSR, km	Low flow time of travel, days	WWTP effluent load *	Load at the BSR *
Alvord wwtp	58.51	2.18	2.55E+10	3.15E+09
Ashton wwtp	110.23	3.58	5.78E+10	1.86E+09
Doon wwtp	43.85	1.20	5.95E+10	1.88E+10
George wwtp	79.29	2.48	1.33E+11	1.23E+10
Hull wwtp	57.71	1.56	2.16E+11	4.84E+10
Lester wwtp	72.97	2.52	3.21E+10	2.86E+09
Little Rock wwtp	110.42	3.77	6.16E+10	1.66E+09
Niessink Home wwtp	41.26	1.01	2.50E+09	9.50E+08
Rock Rapids wwtp	71.32	1.91	3.25E+11	5.20E+10
Rock Valley wwtp	30.39	0.87	3.18E+11	1.37E+11
Sibley wwtp	126.56	4.39	3.52E+11	5.20E+09

*Units for these loads are *E. coli* organisms/day.

Seven of these facilities are controlled discharge lagoons, two are continuous discharge aerated lagoons, and two are continuous discharge trickling filters (See Table 3.4 for wwtp characteristics). In general, controlled discharge lagoons are designed to discharge infrequently, perhaps twice a year, for two or three weeks during higher flows. Discharges are usually in the spring and fall.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.36 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.35 to 3.37 show the delivered loads for the various non-point sources for the 23 HUC 12's in the Iowa Rock River watershed that discharge into the BSRTMDL-3 segment.

Table 3.35 Rock River livestock, wildlife and built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load at BSR *	June load at BSR *	Oct. load at BSR *
1	Burr Oak Creek-Rock River	39.4	7.90E+13	5.46E+13	4.89E+14
2	Unnamed Cr. Dry Run Creek	27.98	8.85E+13	6.64E+13	5.56E+14
3	Dry Run Creek-Rock River	23.03	2.66E+13	9.94E+13	5.03E+14
4	Rock River-Burr Oak Creek	23.03	1.54E+14	1.11E+14	5.73E+14
5	Lower Rock River	0	1.58E+14	1.15E+14	9.82E+14
6	Otter Creek-Rat Creek	42.5	2.19E+13	1.46E+13	1.35E+14
7	Otter Creek-Schutte Creek	42.5	5.83E+12	4.02E+12	3.59E+13
8	Cloverdale Creek	42.5	9.16E+11	4.10E+11	5.19E+12
9	Otter Creek-Kappes Creek	42.5	1.61E+13	1.08E+13	9.88E+13
10	Rat Creek	42.5	4.64E+12	2.56E+12	2.74E+13
11	Rock River	76.5	4.90E+12	3.65E+12	3.05E+13
12	Kanaranzi Creek	76.5	1.80E+12	1.21E+12	1.09E+13
13	Lower Mud Creek	44.58	8.46E+13	6.09E+13	5.25E+14
14	Upper Mud Creek	44.58	1.84E+13	1.36E+13	1.15E+14
15	Middle Mud Creek	44.58	5.91E+13	4.27E+13	3.73E+14
16	Little Rock River	42.5	5.94E+07	5.94E+07	7.11E+07
17	Little Rock River-Snow Creek	42.5	6.92E+12	3.80E+12	4.08E+13
18	Emery Creek	42.5	7.64E+12	5.11E+12	4.81E+13
19	Little Rock River-Whitney Cr.	42.5	1.89E+13	1.30E+13	1.16E+14
20	Tom Creek-Rock River	73.62	2.03E+13	1.20E+13	1.27E+14
21	Unnamed Creek-Rock River	55.02	1.10E+13	7.82E+12	6.81E+13
22	Rock River-Tom Creek	42.19	1.22E+14	8.93E+13	7.61E+14
23	Little Rock River-Emery Creek	42.5	5.76E+13	4.19E+13	3.63E+14

*Units for these loads are *E. coli* organisms/day.

** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.36 Rock River - Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams*	June load, 24% in streams *	Oct. load, 12% in streams*
1	Burr Oak Cr.-Rock River	612	39.4	1.14E+12	2.28E+12	1.14E+12
2	Unnamed Cr.-Dry Run Cr.	725	27.98	1.63E+12	3.27E+12	1.63E+12
3	Dry Run Creek-Rock River	910	23.03	3.08E+12	6.15E+12	3.08E+12
4	Rock River-Burr Oak Cr.	1000	23.03	3.38E+12	6.76E+12	3.38E+12
5	Lower Rock River	755	0	5.89E+12	1.18E+13	5.89E+12
6	Otter Creek-Rat Creek	315	42.5	1.47E+11	2.95E+11	1.47E+11
7	Otter Creek-Schutte Cr.	307	42.5	1.25E+10	2.51E+10	1.25E+10
8	Cloverdale Creek	31	42.5	1.28E+09	2.56E+09	1.28E+09
9	Otter Creek-Kappes Cr.	389	42.5	6.72E+10	1.34E+11	6.72E+10
10	Rat Creek	92	42.5	1.59E+10	3.17E+10	1.59E+10
11	Rock River	76	76.5	3.69E+10	7.38E+10	3.69E+10
12	Kanaranzi Creek	26	76.5	1.24E+10	2.49E+10	1.24E+10
13	Lower Mud Creek	768	44.58	1.19E+12	2.37E+12	1.19E+12
14	Upper Mud Creek	396	44.58	1.12E+11	2.24E+11	1.12E+11
15	Middle Mud Creek	767	44.58	4.58E+11	9.15E+11	4.58E+11
16	Little Rock River	0	42.5	0.00E+00	0.00E+00	0.00E+00
17	Little Rock River-Snow Cr.	155	42.5	2.07E+10	4.14E+10	2.07E+10
18	Emery Creek	75	42.5	5.13E+10	1.03E+11	5.13E+10
19	Little Rock R.-Whitney Cr.	296	42.5	1.38E+11	2.77E+11	1.38E+11
20	Tom Creek-Rock River	134	73.62	7.20E+10	1.44E+11	7.20E+10
21	Unnamed Cr.-Rock River	116	55.02	1.22E+11	2.45E+11	1.22E+11
22	Rock River-Tom Creek	1067	42.19	1.80E+12	3.60E+12	1.80E+12
23	Little Rock R.-Emery Cr.	472	42.5	7.87E+11	1.57E+12	7.87E+11

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle that are assumed to be in the stream.

Table 3.37 Rock River, Failing Septic Systems NPS loads

No.	HUC 12 name	No. of failed septics	Distance to BSR, km	Load at BSR *
1	Burr Oak Creek-Rock River	151	39.4	1.49E+09
2	Unnamed Creek-Dry Run Creek	79	27.98	9.42E+08
3	Dry Run Creek-Rock River	115	23.03	2.06E+09
4	Rock River-Burr Oak Creek	157	23.03	2.81E+09
5	Lower Rock River	125	0	5.18E+09
6	Otter Creek-Rat Creek	195	42.5	4.83E+08
7	Otter Creek-Schutte Creek	185	42.5	4.02E+07
8	Cloverdale Creek	78	42.5	1.70E+07
9	Otter Creek-Kappes Creek	208	42.5	1.90E+08
10	Rat Creek	121	42.5	1.11E+08
11	Rock River	53	76.5	1.35E+08
12	Kanaranzi Creek	39	76.5	1.00E+08
13	Lower Mud Creek	143	44.58	1.17E+09
14	Upper Mud Creek	64	44.58	9.64E+07
15	Middle Mud Creek	172	44.58	5.45E+08
16	Little Rock River	4	42.5	8.44E+05
17	Little Rock River-Snow Creek	173	42.5	1.23E+08
18	Emery Creek	67	42.5	2.43E+08
19	Little Rock River-Whitney Creek	201	42.5	4.98E+08
20	Tom Creek-Rock River	201	73.62	5.76E+08
21	Unnamed Creek-Rock River	63	55.02	3.52E+08
22	Rock River-Tom Creek	220	42.19	1.97E+09
23	Little Rock River-Emery Creek	156	42.5	1.38E+09

*Units for these loads are *E. coli* organisms/day.

Minnesota Pollutant Sources

A large part of the Rock River watershed is in Minnesota and there are three major streams that drain this area; Mud Creek, the mainstem Rock River, and the Little Rock River. These three streams were monitored monthly where they cross the border. The loads from Minnesota are combined point and non-point pollutants at the spot where the streams cross into Iowa. Tables 3.38 to 3.40 show the bacteria die-off over the distance to the Big Sioux River.

Table 3.38 Minnesota High Flow *E. coli* loads at the BSR

Stream	Time of Travel to BSR, days	Measured load at the border	Load at BSR *
Mud Creek	1.792	6.26E+13	1.12E+13
Rock River, mainstem	1.419	2.02E+14	5.16E+13
Little Rock RIver	3.034	1.39E+13	3.71E+11

*Units for these loads are *E. coli* organisms/day.

Table 3.39 Minnesota Low Flow *E. coli* loads at the BSR

Stream	Time of Travel to BSR, days	Measured load at the border *	Load at BSR *
Mud Creek	3.471	1.37E+11	4.89E+09
Rock River, mainstem	2.422	1.14E+12	1.11E+11
Little Rock RIver	4.763	2.04E+11	2.11E+09

*Units for these loads are *E. coli* organisms/day.

Table 3.40 Minnesota Very Low Flow *E. coli* loads at the BSR

Stream	Time of Travel to BSR, days	Measured load at the border *	Load at BSR *
Mud Creek	5.845	2.14E+10	7.83E+07
Rock River, mainstem	3.346	2.45E+11	9.85E+09
Little Rock RIver	4.443	1.36E+11	1.91E+09

*Units for these loads are *E. coli* organisms/day.

3.7.2 Pollution Source Assessment - Direct BSR and Rock River Watershed Loads

The BSRTMDL-3 segment is 21.4 miles long and drains the 23 HUC 12's of the Rock River watershed and 7 HUC 12's that drain directly to the Big Sioux (See Figures 7 and 8). This drainage area is a significant part of the Big Sioux River watershed. There are eleven wastewater treatment plants in the Iowa Rock River watershed and one in the direct draining HUC12's.

Existing Load

The existing load for this segment will be evaluated for the critical flow conditions identified by the load duration curve analysis of monitoring data. At high flow (1% rank) the existing loads for this segment at the SDDENR monitoring sites will be shown in Table 3.41 when it becomes available.

Table 3.41 BSRTMDL-3 High Flow (1% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	High flow median load	Sample maximum load *
Hudson, SD	LBSM09, ambient site	River km 79	Not available**	Not available**
Hawarden, IA	LBSM13	River km 102	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available. .

At low flow (70% rank) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.42 when it becomes available.

Table 3.42 BSRTMDL-3 Low Flow (70% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	Low flow median load *	Sample maximum load *
Hudson, SD	LBSM09, ambient site	River km 79	Not available**	Not available**
Hawarden, IA	LBSM13	River km 102	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum of 235 *E. coli* organisms/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Tables 3.43 and 3.44 show the maximum differences measured in both high (1% rank) and low flow (70%) conditions.

Table 3.43 BSRTMDL-3, High Flow (1%), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Hudson, SD	LBSM09, ambient site	Not available**	Not available**	Not available**
Hawarden, IA	LBSM13	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Table 3.44 BSRTMDL-3, Low Flow (70%), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Hudson, SD	LBSM09, ambient site	Not available**	Not available**	Not available**
Hawarden, IA	LBSM13	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-3 segment are located in Iowa, South Dakota, and Minnesota. The Minnesota loads have been calculated independently and are included as part of the Rock River load at the Big Sioux confluence. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. Each feedlot in the South Dakota watershed was identified and evaluated. This information will eventually be included by SDDENR in a watershed model called Annualized AgNPS (Agriculture NPS) for the South Dakota Big Sioux watershed. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:
The Iowa pollutant sources on this impaired segment consist of the loads from the Big Sioux River upstream of the Rock River as measured at the Hudson monitoring site, the estimated loads from the Rock River watershed, and loads from the seven direct HUC 12 sub-watersheds draining into this segment.

Iowa Point Sources**:** There is one wastewater treatment plant in the BSRTMDL-3 watershed that discharges directly into the Big Sioux River from the City of Hawarden. The Hawarden wastewater treatment plant continuously discharges and is required by its NPDES permit to meet the pathogen indicator WQS limits. The plant disinfects its effluent to meet the water quality standards. There are eleven wastewater treatment facilities in the Rock River Iowa watershed that are discussed in more detail in Section 3.7.1.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.46 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. The NPS loads for the 23 HUC 12's in the Rock River watershed were presented in Tables 3.35 to 3.37. Tables 3.45 to 3.47 show the delivered loads for the various non-point sources for the seven direct HUC 12's on the Iowa side that discharge into the BSRTMDL-3 segment.

Table 3.45 BSRTMDL-3, Livestock, wildlife, built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR **	June load * at BSR **	Oct. load * at BSR **
10	Dry Cr.Big Sioux River	0.00	3.27E+14	2.40E+14	2.12E+15
11	Upper Sixmile Creek	41.58	2.13E+14	1.29E+14	1.30E+15
12	Middle Sixmile Creek	27.71	1.46E+14	1.07E+14	9.30E+14
13	Big Sioux River	0.00	3.15E+12	2.41E+12	2.01E+13
14	Lower Sixmile Creek	0.00	1.29E+14	9.13E+13	8.20E+14
15	Big Sioux River	0.00	3.42E+13	2.58E+13	2.18E+14
18	Big Sioux River	0.00	2.73E+12	1.90E+12	1.92E+13

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.46 BSRTMDL-3, Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
10	Dry Cr. Big Sioux R.	1124	0.00	8.77E+12	1.75E+13	8.77E+12
11	Upper Sixmile Creek	1749	41.58	2.07E+12	4.14E+12	2.07E+12
12	Middle Sixmile Creek	1098	27.71	2.44E+12	4.87E+12	2.44E+12
13	Big Sioux River	14	0.00	1.10E+11	2.21E+11	1.10E+11
14	Lower Sixmile Creek	478	0.00	3.73E+12	7.46E+12	3.73E+12
15	Big Sioux River	150	0.00	1.17E+12	2.33E+12	1.17E+12
18	Big Sioux River	0	0.00	0.00E+00	0.00E+00	0.00E+00

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle that are assumed to be in the stream.

Table 3.47 BSRTMDL-3, Failing Septic systems NPS loads

No.	HUC 12 name	No. of failed septics	Distance to BSR, km	Load at BSR *
10	Dry Creek-Big Sioux River	263	0.00	1.17E+10
11	Upper Sixmile Creek	187	41.58	1.27E+09
12	Middle Sixmile Creek	173	27.71	2.19E+09
13	Big Sioux River	43	0.00	1.91E+09
14	Lower Sixmile Creek	204	0.00	9.10E+09
15	Big Sioux River	34	0.00	1.53E+09
18	Big Sioux River	25	0.00	1.12E+09

*Units for these loads are *E. coli* organisms/day.

South Dakota Pollutant Sources

The South Dakota flows and loads for this segment consist of the loads measured at Finnie Creek and at Green Creek near their confluences with the Big Sioux River and the direct HUC 12 loads. Estimates of these loads will be made by SDDENR and then summarized in Table 3.48 when available.

Table 3.48 BSRTMDL-3, South Dakota Pollutant Load Estimates

Pollutant Source	**Location**	**SDDENR site no.**	**High flow (1% rank) load ***	**Low flow (70% rank) load ***
Finnie Creek	River km 95	LBST11	Not available**	Not available**
Green Creek	River km 104	LBST12	Not available**	Not available**
Direct HUC 12's	Incremental***	NA	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.
***Loads to the BSR from adjoining HUC 12's are incrementally distributed along the BSR length in bacteria load per km.

3.7.3 Pollutant Allocations

Wasteload Allocations, Rock River Watershed

Rock River Watershed Wastewater Treatment Plant Load Allocations: The wasteload allocations (WLA) for the eleven Iowa wastewater treatment plants in the Rock River sub-watershed contributing loads to the BSRTMDL-3 segment are based on the standard assumption that effluent concentration must meet the water quality standard at the point where it enters a stream that has the Class A1 Primary Contact Recreational Use designation. Therefore, the WLA for a plant discharging directly into a classified stream would be the same as the numeric E. coli water quality standard. The wastewater treatment plant E. coli loads delivered to the BSRTMDL-3 segment and the distance of the plant discharge from the BSR is shown in Table 3.34 in Section 3.7.1 Pollution Source Assessment, Rock River Watershed.

Wasteload allocations for discharges some distance from the designated use waterbody (BSR) are calculated using the estimated time of travel between the discharge location and the Big Sioux River and a bacteria die-off factor. The time of travel estimates for the eleven BSRTMDL-3 wastewater treatment plants in the Rock River watershed used time of travel calculations for the relevant segments of Mud Creek, the Rock River, and the Little Rock River. (See the spreadsheets *Mud Time of Travel.xls, Rock Time of Travel.xls, Little Rock Time of Travel.xls,* and *Rock wwtp.xls* listed in Appendix A.) The time of travel estimates for the three streams were calculated from flow monitoring data stratified into three categories; high flow, low flow, and very low flow.

Wasteload allocations were calculated for the most stringent condition, which is low flow. At high flow, the load from these small facilities is not over the E. coli standard and is also dwarfed by the surface run-off loads. At very low flow, the reduced stream velocity allows for greater die-off so the allocation concentration at the discharge location is higher (less stringent) than for low flow.

All of the wwtp discharges in the Rock River watershed to the Big Sioux River are indirect. For indirect discharges, the time of travel has been estimated at low flow and die-off has been back calculated from the Big Sioux River upstream to the discharge location. The calculations and assumptions used in the development of wasteload allocations are in the time of travel and bacteria die-off sections of Appendix B, Procedures and Assumptions.

These WLA's apply from March 15 through November 15 and are intended to provide *E. coli* and fecal coliform concentrations at the confluence with the Big Sioux River that complies with the *E. coli* Water Quality Standards (WQS). The WQS values for *E. coli* are a geometric mean of 126-organisms/100 ml and a sample maximum of 235-organisms/100 ml. The WLA's for the Rock River watershed BSRTMDL-3 wastewater treatment plants are in Table 3.49.

Table 3.49 BSRTMDL-3, Rock River Low Flow Wasteload Allocations

Name	**WQS load at BSR, *E. coli* org/day ***	**WLA at wwtp location, *E. coli* org./day ****	**WLA geometric mean, *E. coli* org/100 ml *****	**WLA sample max. *E. coli* org/100 ml *****
Alvord wwtp	1.19E+09	9.67E+09	**1022**	**1910**
Ashton wwtp	2.14E+09	6.64E+10	**none**	**none**
Doon wwtp	2.10E+09	6.65E+09	**399**	**747**
George wwtp	6.00E+09	6.48E+10	**1361**	**2545**
Hull wwtp	2.10E+09	9.35E+09	**561**	**1049**
Lester wwtp	1.43E+09	1.61E+10	**1416**	**2647**
Little Rock wwtp	2.67E+09	9.93E+10	**none**	**none**
Niessink wwtp	9.54E+07	2.51E+08	**332**	**620**
Rock Rapids wwtp	2.39E+09	1.50E+10	**788**	**1474**
Rock Valley wwtp	3.42E+09	7.91E+09	**291**	**544**
Sibley wwtp	3.20E+09	2.16E+11	**8524**	**15940**

*This is the allowable total daily load for the wwtp in *E. coli* organisms per day for the design plant flow at the WQS concentration of 126 E. coli organisms/100ml.
**This is the allowable total daily load at the effluent discharge location after die-off has been calculated at low flow time of travel.
***Concentration WLA are based on the E. coli numeric WQS values of 126-organisms/100 ml for geometric mean and 235-organisms/100 ml for the sample maximum and accounting for die-off between the discharge and the BSR. Apply from March 15 to November 15.

<u>Rock River Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations</u>: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The

thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There are seven NPDES permitted animal feeding operation facilities in the Rock River watershed that drains to the BSRTMDL-3 impaired segment. The wasteload allocations for these facilities follow state (IAC 567- Ch.65) and federal (40 CFR 125.30 through 125.32) rules for open feedlots. The relevant state rule, IAC 567 – 65.101(2) a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facilities, their locations and HUC 12, and WLA's are shown in Table 3.50.

Table 3.50 BSRTMDL-3 Rock River Watershed NPDES Permitted Animal Feeding Operation Facilities

Facility Name	Facility ID	NPDES #	EPA #	Township and range	Sec	1/4 Sec	HUC 12*	WLA **
Jansma Cattle Co.	61304	60-00-0-04	77640	T99N R45W	7&6	SW-NE	RR #22	No discharge
Rock River Feedyards	56382	60-00-0-06	79022	T99N R46W	10	NE	RR #15	No discharge
John Fluit, Jr. Feedlot	56833	60-00-0-08(2)	79685	T98N R47W	16	SW	RR #3	No discharge
East Valley Farm, Inc	56490	84-00-0-27	78107	T96N R46W	2	NE	RR #4	No discharge
Fairview Feeders	62532	84-00-0-30	78379	T97N R47W	16	NW	RR #2	No discharge
Sunrise Feedlots, Inc	56715	84-00-0-35	79103	T97N R45W	17,18	NW, NE	RR #1	No discharge
Performance Beef	61089	84-00-0-26	77704	T97N R47W	14	NE	RR #3	No discharge

*This refers to the HUC 12 sub-watershed in the Rock River watershed and corresponds to the HUC 12 number in column one of Table 3.52.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Wasteload Allocations, BSR Direct Watershed

Wastewater Treatment Plant Wasteload Allocations: The Hawarden wastewater treatment plant is the only one on the BSRTMDL-3 segment that discharges directly to the Big Sioux River. This plant already has a wasteload allocation and NPDES permit limit that limits effluent *E. coli* to the water quality standard values during the primary contact recreational season from March 15 to November 15. Therefore a new wasteload allocation is not necessary for this facility.

BSR Direct Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There are six NPDES permitted animal feeding operation facilities in the BSR direct watershed that drains to the BSRTMDL-3 impaired segment. The wasteload allocations for these facilities follow state (IAC 567- Ch.65) and federal (40 CFR 125.30 through 125.32) rules for open feedlots. The relevant state rule, IAC 567 – 65.101(2) a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facilities, their locations and HUC 12, and WLA's are shown in Table 3.51.

Table 3.51 BSRTMDL-3 BSR direct Watershed NPDES Permitted Animal Feeding Operation Facilities Wasteload Allocations

Facility Name	Facility ID	NPDES #	EPA #	Township and range	Sec	1/4 Sec	HUC 12*	WLA**
Farmer's Coop Society	60404	84-00-0-12	77577	T96N R46W	36	NW	BSR #11	No discharge
Remmerde Farms	56481	84-00-0-29	78387	T96N R46W	10	NE	BSR #10	No discharge
Jeff Eilts Feedlot	56276	84-00-0-37	79189	T95N, R46W	33	SW	BSR #12	No discharge
Van Berkel Farms	56294	84-00-0-40	79464	T96N R46W	31	NE	BSR #10	No discharge
Halverhals Feedlot	59740	84-00-0-42	79499	T95N R46W	6	SW	BSR #12	No discharge
Rolling Hills Feedlot	56731	84-00-0-39	79341	T94N R47W	4	NW	BSR #14	No discharge

*This refers to the HUC 12 sub-watershed in the BSR direct watershed and corresponds to the HUC 12 number in column one of Table 3.59.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocations and Pollutant Load Reductions Needed
The load allocations for TMDL 3 have been calculated and distributed to the loads from the Rock River tributary watershed and the HUC 12 sub-watersheds that discharge directly to the Big Sioux River.

<u>Rock River Load Allocations</u>
The load allocations for the Rock River at its confluence with the Big Sioux are based on the discharges from the 23 Iowa HUC 12s that discharge to the Rock River and then to the Big Sioux BSRTMDL-3 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves (spreadsheet *stream data analysis.xls*) for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions.

These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.52 through 3.55). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.52 BSRTMDL-3 – Rock R. Allocations and Reductions for 1% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	4.64E+11	5.69E+13	99.2%
2	Unnamed Creek-Dry Run Creek	2.42E+11	6.97E+13	99.8%
3	Dry Run Creek-Rock River	3.53E+11	1.06E+14	99.7%
4	Rock River-Burr Oak Creek	4.82E+11	1.18E+14	99.6%
5	Lower Rock River	3.85E+11	1.27E+14	99.7%
6	Otter Creek-Rat Creek	5.98E+11	1.49E+13	96.0%
7	Otter Creek-Schutte Creek	5.69E+11	4.05E+12	86.0%
8	Cloverdale Creek	2.41E+11	4.13E+11	41.6%
9	Otter Creek-Kappes Creek	6.39E+11	1.09E+13	94.2%
10	Rat Creek	3.72E+11	2.59E+12	85.6%
11	Rock River	1.62E+11	3.73E+12	95.7%
12	Kanaranzi Creek	1.20E+11	1.23E+12	90.3%
13	Lower Mud Creek	4.38E+11	6.33E+13	99.3%
14	Upper Mud Creek	1.97E+11	1.38E+13	98.6%
15	Middle Mud Creek	5.29E+11	4.36E+13	98.8%
16	Little Rock River	1.10E+10	6.02E+07	none
17	Little Rock River-Snow Creek	5.32E+11	3.84E+12	86.2%
18	Emery Creek	2.06E+11	5.21E+12	96.0%
19	Little Rock River-Whitney Creek	6.17E+11	1.33E+13	95.4%
20	Tom Creek-Rock River	6.19E+11	1.21E+13	94.9%
21	Unnamed Creek-Rock River	1.92E+11	8.07E+12	97.6%
22	Rock River-Tom Creek	6.79E+11	9.29E+13	99.3%
23	Little Rock River-Emery Creek	4.79E+11	4.35E+13	98.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.53 BSRTMDL-3 – Rock R. Allocations and Reductions for 10% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	9.39E+10	3.85E+12	97.6%
2	Unnamed Creek-Dry Run Creek	4.90E+10	5.17E+12	99.1%
3	Dry Run Creek-Rock River	7.15E+10	9.00E+12	99.2%
4	Rock River-Burr Oak Creek	9.77E+10	9.94E+12	99.0%
5	Lower Rock River	7.80E+10	1.51E+13	99.5%
6	Otter Creek-Rat Creek	1.21E+11	7.12E+11	83.0%
7	Otter Creek-Schutte Creek	1.15E+11	1.40E+11	17.7%
8	Cloverdale Creek	4.88E+10	1.43E+10	none
9	Otter Creek-Kappes Creek	1.29E+11	4.43E+11	70.8%
10	Rat Creek	7.54E+10	1.05E+11	28.1%
11	Rock River	3.28E+10	1.78E+11	81.6%
12	Kanaranzi Creek	2.43E+10	5.95E+10	59.2%
13	Lower Mud Creek	8.87E+10	4.12E+12	97.8%
14	Upper Mud Creek	3.99E+10	6.13E+11	93.5%
15	Middle Mud Creek	1.07E+11	2.14E+12	95.0%
16	Little Rock River	2.22E+09	2.54E+06	none
17	Little Rock River-Snow Creek	1.08E+11	1.50E+11	28.2%
18	Emery Creek	4.17E+10	2.49E+11	83.2%
19	Little Rock River-Whitney Creek	1.25E+11	6.49E+11	80.7%
20	Tom Creek-Rock River	1.25E+11	4.86E+11	74.2%
21	Unnamed Creek-Rock River	3.90E+10	4.69E+11	91.7%
22	Rock River-Tom Creek	1.37E+11	6.15E+12	97.8%
23	Little Rock River-Emery Creek	9.71E+10	2.77E+12	96.5%

*Units for these loads are *E. coli* organisms/day.

Table 3.54 BSRTMDL-3 – Rock R. Allocations and Reductions for 50% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	3.52E+10	2.44E+12	98.6%
2	Unnamed Creek-Dry Run Creek	1.84E+10	3.46E+12	99.5%
3	Dry Run Creek-Rock River	2.68E+10	6.44E+12	99.6%
4	Rock River-Burr Oak Creek	3.66E+10	7.08E+12	99.5%
5	Lower Rock River	2.93E+10	1.21E+13	99.8%
6	Otter Creek-Rat Creek	4.54E+10	3.37E+11	86.5%
7	Otter Creek-Schutte Creek	4.32E+10	3.66E+10	none
8	Cloverdale Creek	1.83E+10	3.75E+09	none
9	Otter Creek-Kappes Creek	4.86E+10	1.65E+11	70.6%
10	Rat Creek	2.83E+10	3.91E+10	27.7%
11	Rock River	1.23E+10	8.44E+10	85.4%
12	Kanaranzi Creek	9.10E+09	2.84E+10	68.0%
13	Lower Mud Creek	3.33E+10	2.55E+12	98.7%
14	Upper Mud Creek	1.50E+10	2.63E+11	94.3%
15	Middle Mud Creek	4.02E+10	1.04E+12	96.1%
16	Little Rock River	8.34E+08	1.01E+06	none
17	Little Rock River-Snow Creek	4.04E+10	5.24E+10	22.9%
18	Emery Creek	1.56E+10	1.17E+11	86.7%
19	Little Rock River-Whitney Creek	4.68E+10	3.14E+11	85.1%
20	Tom Creek-Rock River	4.70E+10	1.79E+11	73.7%
21	Unnamed Creek-Rock River	1.46E+10	2.68E+11	94.5%
22	Rock River-Tom Creek	5.15E+10	3.85E+12	98.7%
23	Little Rock River-Emery Creek	3.64E+10	1.69E+12	97.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.55 BSRTMDL-3 – Rock R. Allocations and Reductions for 70% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	2.35E+10	2.30E+12	99.0%
2	Unnamed Creek-Dry Run Creek	1.22E+10	3.29E+12	99.6%
3	Dry Run Creek-Rock River	1.79E+10	6.18E+12	99.7%
4	Rock River-Burr Oak Creek	2.44E+10	6.79E+12	99.6%
5	Lower Rock River	1.95E+10	1.18E+13	99.8%
6	Otter Creek-Rat Creek	3.03E+10	2.99E+11	89.9%
7	Otter Creek-Schutte Creek	2.88E+10	2.63E+10	none
8	Cloverdale Creek	1.22E+10	2.70E+09	none
9	Otter Creek-Kappes Creek	3.24E+10	1.38E+11	76.5%
10	Rat Creek	1.89E+10	3.25E+10	42.1%
11	Rock River	8.19E+09	7.50E+10	89.1%
12	Kanaranzi Creek	6.07E+09	2.53E+10	76.0%
13	Lower Mud Creek	2.22E+10	2.39E+12	99.1%
14	Upper Mud Creek	9.98E+09	2.28E+11	95.6%
15	Middle Mud Creek	2.68E+10	9.28E+11	97.1%
16	Little Rock River	5.56E+08	8.61E+05	none
17	Little Rock River-Snow Creek	2.69E+10	4.26E+10	36.9%
18	Emery Creek	1.04E+10	1.04E+11	90.0%
19	Little Rock River-Whitney Creek	3.12E+10	2.81E+11	88.9%
20	Tom Creek-Rock River	3.13E+10	1.48E+11	78.8%
21	Unnamed Creek-Rock River	9.74E+09	2.48E+11	96.1%
22	Rock River-Tom Creek	3.44E+10	3.62E+12	99.1%
23	Little Rock River-Emery Creek	2.43E+10	1.59E+12	98.5%

*Units for these loads are *E. coli* organisms/day.

Minnesota load allocations:

The Minnesota calculations for high, low and very low flow loads were based on monitored high flow event data and monthly measurements near where the three streams cross the border into Iowa. Time of travel was estimated and a bacteria die-off function was used to derive an allocation at the border from the water quality standard target sample maximum 235 *E. coli* organisms/100 ml at the Big Sioux River. These flow conditions and time of travel derivations can be found in Appendix B, Procedures and Assumptions. The Minnesota load allocations are shown in Tables 3.56 to 3.58.

Table 3.56 High flow - Minnesota Load Allocations

Stream	Load allocation at BSR *	Load allocation at MN border *	Load reduction needed
Mud Creek	3.80E+11	2.12E+12	96.6
Rock River, mainstem	3.30E+12	1.29E+13	93.6
Little Rock RIver	1.61E+11	6.04E+12	56.6

*Units for these loads are *E. coli* organisms/day.

Table 3.57 Low flow - Minnesota Load Allocations

Stream	Load allocation at BSR *	Load allocation at MN border*	Load reduction needed
Mud Creek	3.68E+10	1.03E+12	none
Rock River, mainstem	6.68E+11	6.83E+12	none
Little Rock RIver	8.63E+10	8.35E+12	none

*Units for these loads are *E. coli* organisms/day.

Table 3.58 Very Low flow - Minnesota Load Allocations

Stream	Load allocation at BSR *	Load allocation at MN border *	Load reduction needed
Mud Creek	5.75E+09	1.57E+12	none
Rock River, mainstem	1.44E+11	3.57E+12	none
Little Rock RIver	5.75E+10	4.09E+12	none

*Units for these loads are *E. coli* organisms/day.

<u>Direct Discharging HUC 12 Sub-watershed Load Allocations</u>

The load allocations for the seven Iowa HUC 12 sub-watersheds that discharge directly to the Big Sioux River BSRTMDL-3 segment are in Tables 3.59 to 3.62. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.59 through 3.62). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.59 BSRTMDL-3 BSR Direct Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	5.98E+11	2.58E+14	99.8%
11	Upper Sixmile Creek	4.26E+11	1.33E+14	99.7%
12	Middle Sixmile Creek	3.92E+11	1.12E+14	99.6%
13	Big Sioux River	9.72E+10	2.63E+12	96.3%
14	Lower Sixmile Creek	4.64E+11	9.87E+13	99.5%
15	Big Sioux River	7.79E+10	2.81E+13	99.7%
18	Big Sioux River	5.69E+10	1.90E+12	97.0%

*Units for these loads are *E. coli* organisms/day.

Table 3.60 BSRTMDL-3 BSR Direct Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	1.21E+11	2.44E+13	99.5%
11	Upper Sixmile Creek	8.62E+10	7.82E+12	98.9%
12	Middle Sixmile Creek	7.94E+10	7.92E+12	99.0%
13	Big Sioux River	1.97E+10	2.91E+11	93.2%
14	Lower Sixmile Creek	9.40E+10	1.01E+13	99.1%
15	Big Sioux River	1.58E+10	3.07E+12	99.5%
18	Big Sioux River	1.15E+10	5.53E+10	79.2%

*Units for these loads are *E. coli* organisms/day.

Table 3.61 BSRTMDL-3 BSR Direct Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	4.54E+10	1.82E+13	99.8%
11	Upper Sixmile Creek	3.23E+10	4.51E+12	99.3%
12	Middle Sixmile Creek	2.98E+10	5.18E+12	99.4%
13	Big Sioux River	7.39E+09	2.29E+11	96.8%
14	Lower Sixmile Creek	3.52E+10	7.73E+12	99.5%
15	Big Sioux River	5.91E+09	2.41E+12	99.8%
18	Big Sioux River	4.32E+09	6.54E+09	33.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.62 BSRTMDL-3 BSR Direct Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	3.03E+10	1.76E+13	99.8%
11	Upper Sixmile Creek	2.16E+10	4.18E+12	99.5%
12	Middle Sixmile Creek	1.99E+10	4.91E+12	99.6%
13	Big Sioux River	4.92E+09	2.23E+11	97.8%
14	Lower Sixmile Creek	2.35E+10	7.49E+12	99.7%
15	Big Sioux River	3.94E+09	2.34E+12	99.8%
18	Big Sioux River	2.88E+09	1.66E+09	none

*Units for these loads are *E. coli* organisms/day.

3.8 BSRTMDL-4: The Big Sioux River from Indian Creek to Brule Creek.

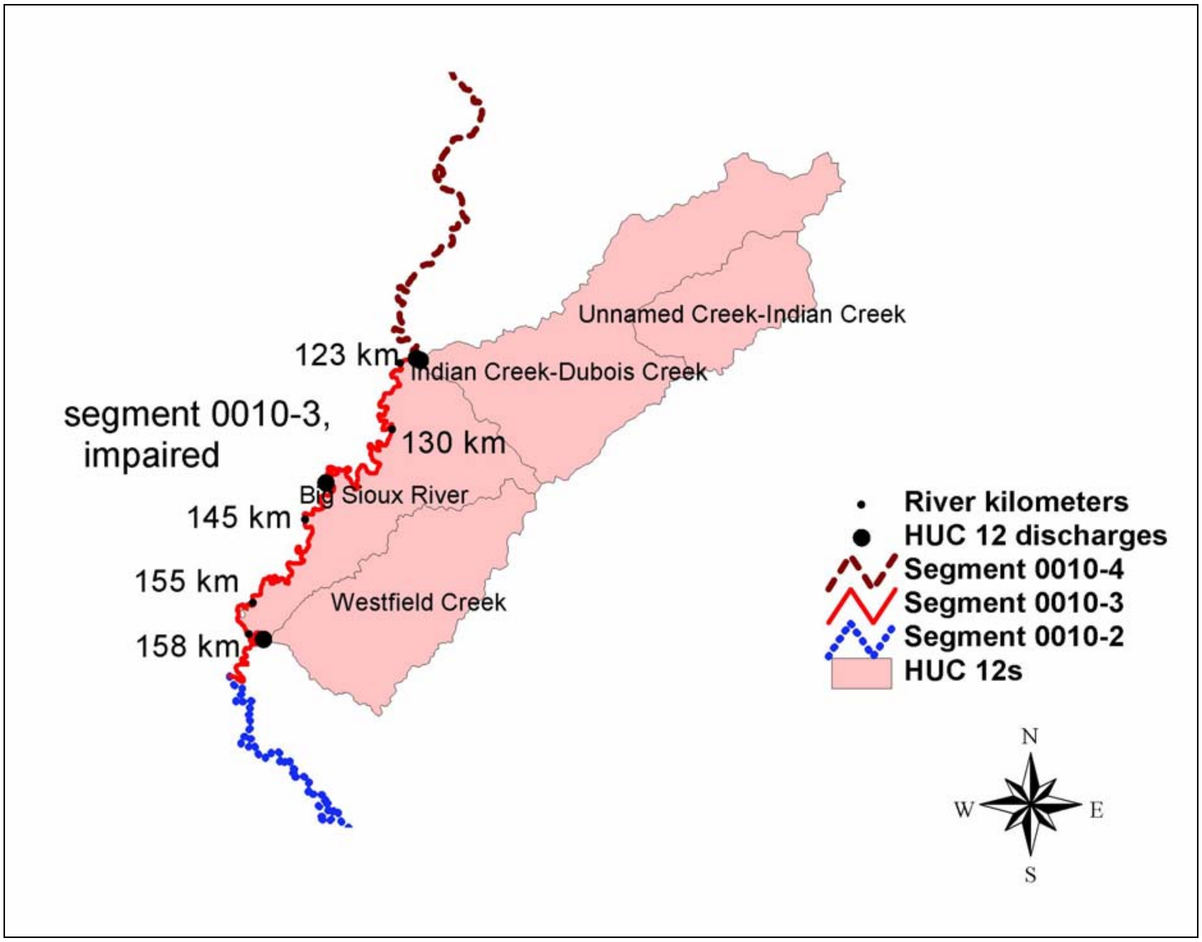

Figure 9. BSRTMDL-4. Indian Creek to Brule Creek

3.8.1 Pollution Source Assessment

The BSRTMDL-4 segment is 25.6 miles long and drains four HUC 12's in the Big Sioux River Iowa watershed as shown in Figure 9. The drainage area is 76,300 acres and there are three wastewater treatment plants in the segment's sub-watershed.

Existing Load

The existing load for this segment will be evaluated for the critical flow conditions identified by the load duration curve analysis of monitoring data. At high flow (1%) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.63 when available.

Table 3.63 BSRTMDL-4, High Flow (1% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	High flow median load*	Sample maximum load *
USGS gage at Akron, IA	LBSM17	River km 136	Not available**	Not available**
Westfield Creek, IA	LBSM19	River km 160	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

At low flow (70%) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.64 when available.

Table 3.64 BSRTMDL-4, Low Flow (70% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	High flow median load *	Sample maximum load *
USGS gage at Akron, IA	LBSM17	River km 136	Not available**	Not available**
Westfield Creek, IA	LBSM19	River km 160	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum load of 235 *E. coli* organisms/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum load concentration and the monitored concentration for a given stream volume or flow rate. Tables 3.65 and 3.66 will show the maximum differences measured in both high (1% rank) and low flow (70% rank) conditions when South Dakota data becomes available.

Table 3.65 BSRTMDL-4, High Flow (1% rank), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
USGS gage at Akron, IA	LBSM17	Not available**	Not available**	Not available**
Westfield Creek, IA	LBSM19	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Table 3.66 BSRTMDL-4, Low Flow (70%), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
USGS gage at Akron, IA	LBSM17	Not available**	Not available**	Not available**
Westfield Creek, IA	LBSM19	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-4 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. Each feedlot in the South Dakota watershed was identified and evaluated. This information will eventually be included by SDDENR in a watershed model called Annualized AgNPS (Agriculture NPS) for the South Dakota Big Sioux watershed. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:

The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from the BSTTMDL 3 segment, loads from three wastewater treatment plants, and non-point sources discharging from this segment's four HUC 12 sub-watersheds.

Iowa Point Sources: There are three wastewater treatment plants in the BSRTMDL-4 watershed. The distance of each of these from the Big Sioux River has been measured and the delivered load calculated using time of travel and an assumed die-off coefficient of 0.96 per day during low flow conditions when continuous sources have their greatest impact. Appendix B, Procedures and Assumptions explains the evaluation spreadsheets and the assumptions, modeling equations, and rationale for plant treatment reductions. Table 3.67 shows the delivered loads assuming no effluent disinfection.

Table 3.67 BSRTMDL-4, Wastewater treatment plant *E. coli* loads at BSR

NAME	distance to BSR, km	Low flow time of travel, days	Wwtp effluent load	Load at the BSR
Akron wwtp	0.00	0.00	1.83E+11	1.83E+11
Ireton wwtp	29.24	1.914	7.52E+10	1.20E+10
Westfield wwtp	0.00	0.00	2.02E+10	2.02E+10

Two of these facilities are controlled discharge lagoons and one is a continuous discharge trickling filters (See Table 3.5 for wwtp characteristics). In general, controlled discharge lagoons are designed to discharge infrequently, perhaps twice a year, for two or three weeks during higher flows. Discharges are usually in the spring and fall. None of these facilities disinfects its effluent.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.69 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.68 to 3.70 show the delivered loads for the various non-point sources for the four HUC 12's on the Iowa side that discharge into the BSRTMDL-4 segment.

Table 3.68 BSRTMDL-4, Livestock, wildlife, built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load* at BSR**,	June load*at BSR**	Oct. load* at BSR**
16	Indian Cr.-Dubois Cr.	0	4.71E+13	3.33E+13	3.02E+14
17	Unnamed Cr.-Indian Cr.	19.16	6.19E+12	3.50E+12	3.68E+13
19	Big Sioux River	0	6.52E+12	3.16E+12	3.84E+13
21	Westfield Creek	0	3.46E+12	1.12E+12	1.90E+13

*Units for these loads are *E. coli* organisms/day.

** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.69 BSRTMDL-4, Cattle in streams NPS loads

No.	HUC name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
16	Indian Cr.-Dubois Cr.	161	0	1.26E+12	2.52E+12	1.26E+12
17	Unnamed Cr.-Indian Cr	33	19.16	1.08E+11	2.17E+11	1.08E+11
19	Big Sioux River	15	0	1.19E+11	2.38E+11	1.19E+11
21	Westfield Creek	5	0	4.04E+10	8.08E+10	4.04E+10

*Units for these loads are *E. coli* organisms/day. The percentage is the fraction of grazing cattle that are in the stream.

Table 3.70 BSRTMDL-4, Failing Septic systems NPS loads

No.	HUC name	# of failed septics	distance to BSR, km	load at BSR *
16	Indian Creek-Dubois Creek	243	0	1.08E+10
17	Unnamed Creek-Indian Creek	83	19.16	1.56E+09
19	Big Sioux River	143	0	6.39E+09
21	Westfield Creek	153	0	6.83E+09

*Units for these loads are *E. coli* organisms/day.

<u>South Dakota Pollutant Sources</u>

The South Dakota pollutant sources for this segment consist of the loads measured at Union and Brule Creeks near their confluences with the Big Sioux River and the direct HUC 12 loads. Estimates of these loads will be made by SDDENR and will be in Table 3.71 when available.

Table 3.71 BSRTMDL-4, South Dakota Pollutant Load Estimates

Pollutant Source	Location	SDDENR site no.	High flow (1%) load *	Low flow (70%) load *
Union Creek	River km 141	LBST16	Not available**	Not available**
Brule Creek	River km 165	LBST15	Not available**	Not available**
Direct HUC 12's	Incremental ***	NA	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.
***Loads to the BSR from adjoining HUC 12's are incrementally distributed along the BSR length by bacteria load per km.

3.8.2 Pollutant Allocations

Wasteload Allocations

<u>Wastewater Treatment Plant Wasteload Allocations</u>: The wasteload allocations (WLA) for the three wastewater treatment plants in the BSRTMDL-4 segment sub-watershed are based on the standard assumption that effluent concentration must meet the water quality standard at the point where it enters a stream that has the Class A1 Primary Contact Recreational Use designation. Therefore, the WLA for a plant discharging directly into a classified stream would be the same as the numeric E. coli water quality standard. Two of the three wastewater treatment plants

discharge directly to the Big Sioux River. These are the Akron and Westfield facilities. The Ireton wwtp is 29 km from the BSR. *E. coli* loads delivered to the BSRTMDL-4 segment are shown in Table 3.67 in Section 3.8.1 Pollution Source Assessment.

Wasteload allocations for the Ireton plant are calculated using the estimated time of travel between the discharge location and the Big Sioux River and a bacteria die-off factor. The time of travel estimates for the wastewater treatment plant used time of travel calculations for segments of Mud Creek similar to the stream receiving the plant effluent. (See the spreadsheets *Mud Time of Travel.xls* and *BSR direct wwtp.xls* listed in Appendix A.) The Mud Creek time of travel estimate was calculated from flow monitoring data stratified into three categories; high flow, low flow, and very low flow.

Wasteload allocations were calculated for the most stringent condition, which is low flow. At high flow, the load from small facilities is not over the E. coli standard and is also dwarfed by the surface run-off loads. At very low flow, the reduced stream velocity allows for greater die-off so the allocation concentration at the discharge location is higher (less stringent) than for low flow.

For the indirect discharge, the time of travel has been estimated at low flow and die-off has been back calculated from the Big Sioux River upstream to the discharge location. The calculations and assumptions used in the development of wasteload allocations are in the time of travel and bacteria die-off sections of Appendix B, Procedures and Assumptions.

These WLA's apply from March 15 through November 15 and are intended to provide *E. coli* and fecal coliform concentrations at the BSR confluence that complies with the *E. coli* Water Quality Standards (WQS). The WQS values for *E. coli* are a geometric mean of 126-organisms/100 ml and a sample maximum of 235-organisms/100 ml. The WLA's for the BSRTMDL-4 wastewater treatment plants are in Table 3.72.

Table 3.72 BSRTMDL-4 Low Flow Wasteload Allocations

Name	WQS load at BSR, *E. coli* org/day *	WLA at wwtp location, *E. coli* org./day **	WLA geometric mean, *E. coli* org/100 ml ***	WLA sample max. *E. coli* org/100 ml ***
Akron wwtp	1.03E+10	1.03E+10	**126**	**235**
Ireton wwtp	6.34E+08	3.97E+09	**788**	**1474**
Westfield wwtpTP	8.39E+08	8.39E+08	**126**	**235**

*This is the allowable total daily load for the wwtp in *E. coli* organisms per day for the design plant flow at the WQS concentration of 126 E. coli organisms/100ml.
**This is the allowable total daily load at the effluent discharge location after die-off has been calculated at low flow time of travel.
***Concentration WLA are based on the E. coli numeric WQS values of 126-organisms/100 ml for geometric mean and 235-organisms/100 ml for the sample maximum and accounting for die-off between the discharge and the BSR. Apply from March 15 to November 15.

Load Allocations and Pollutant Load Reductions Needed

The load allocations for this TMDL are based on the discharges from the eight Iowa HUC 12s that discharge to the BSRTMDL-4 segment and the loads from the South Dakota hydrologic units, tributary streams, and the BSRTMDL-3 segment of the Big Sioux River itself where it crosses into the BSRTMDL-4 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.73 through 3.76). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.73 BSRTMDL-4 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	5.53E+11	3.59E+13	98.5%
17	Unnamed Creek-Indian Creek	1.90E+11	3.72E+12	94.9%
19	Big Sioux River	3.26E+11	3.40E+12	90.4%
21	Westfield Creek	3.48E+11	1.20E+12	71.1%

*Units for these loads are *E. coli* organisms/day.

Table 3.74 BSRTMDL-4 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	1.12E+11	3.48E+12	96.8%
17	Unnamed Creek-Indian Creek	3.84E+10	3.18E+11	87.9%
19	Big Sioux River	6.60E+10	3.35E+11	80.3%
21	Westfield Creek	7.05E+10	1.20E+11	41.0%

*Units for these loads are *E. coli* organisms/day.

Table 3.75 BSRTMDL-4 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	4.20E+10	2.62E+12	98.4%
17	Unnamed Creek-Indian Creek	1.44E+10	2.28E+11	93.7%
19	Big Sioux River	2.47E+10	2.53E+11	90.2%
21	Westfield Creek	2.65E+10	9.08E+10	70.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.76 BSRTMDL-4 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	2.80E+10	2.54E+12	98.9%
17	Unnamed Creek-Indian Creek	9.60E+09	2.19E+11	95.6%
19	Big Sioux River	1.65E+10	2.45E+11	93.3%
21	Westfield Creek	1.76E+10	8.80E+10	79.9%

*Units for these loads are *E. coli* organisms/day.

3.9 BSRTMDL-5: The Big Sioux River from Brule Creek to the Missouri River

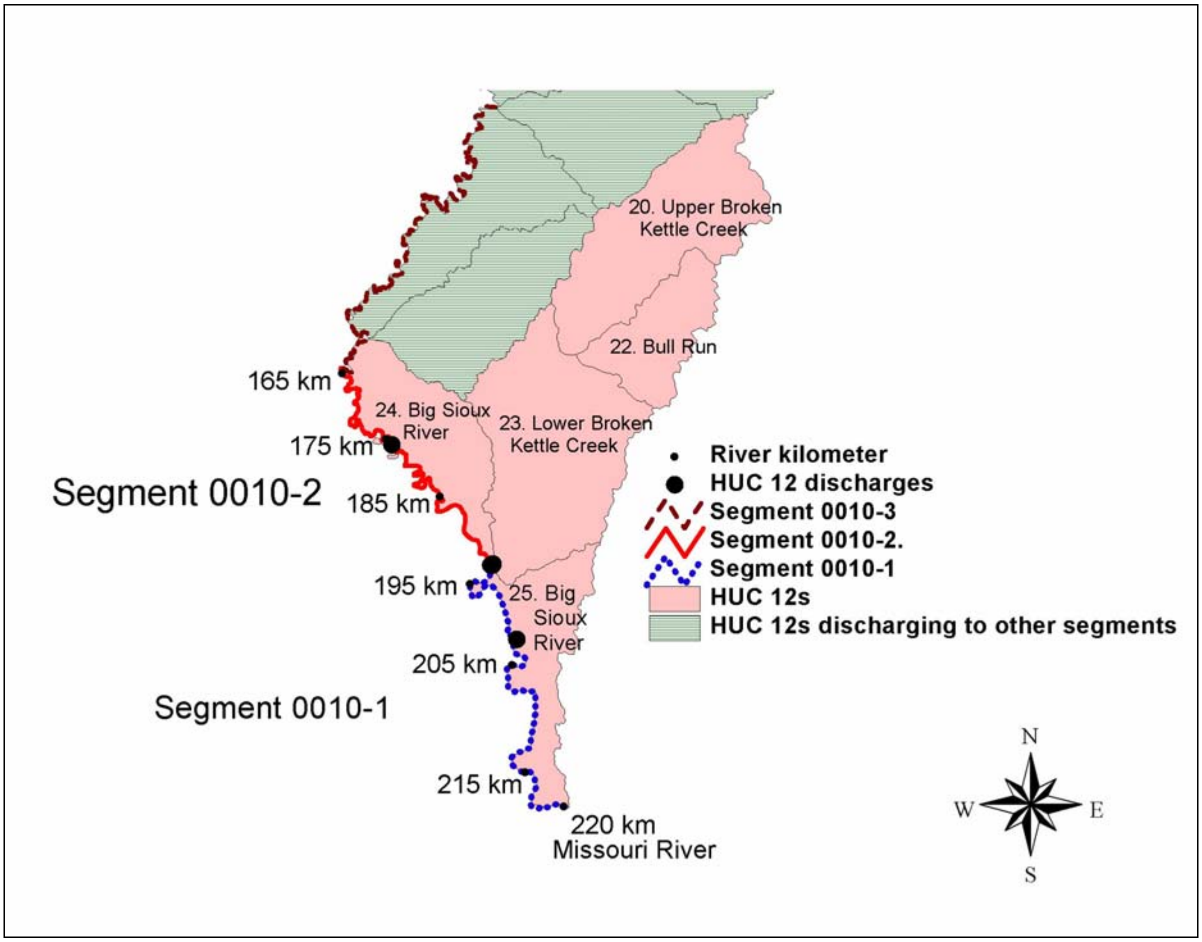

Figure 10. BSRTMDL-5, Brule Creek to the Missouri River Confluence

3.9.1 Pollution Source Assessment

The BSRTMDL-5 segment is 34.7 miles long and drains five HUC 12's in the Big Sioux River Iowa watershed as shown in Figure 10. The drainage area is 90,640 acres (142 square miles) and there are not any NPDES permitted wastewater treatment plants in the segment's sub-watershed.

Existing Load

The existing load for this segment will be evaluated for the critical flow conditions identified by the load duration curve analysis of monitoring data. At high flow (1% rank) the existing load for this segment is at the SDDENR monitoring sites will be shown in Table 3.77 when available. .

Table 3.77 BSRTMDL-5, High Flow (1% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	High flow median load *	Sample maximum load *
Westfield Creek, IA	LBSM19	River km 160	Not available**	Not available**
Broken Kettle Creek, IA	LBSM 20	River km 193	Not available**	Not available**
N. Sioux City, IA	LBSM21	River km 209	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

At low flow (70% rank) the existing load for this segment at the SDDENR monitoring sites will be shown in Table 3.78 when available.

Table 3.78 BSRTMDL-5, Low Flow (70% rank), Existing Loads

Monitoring site location	SDDENR site no.	Location	Low flow median load	Sample maximum load
Westfield Creek, IA	LBSM19	River km 160	Not available**	Not available**
Broken Kettle Creek, IA	LBSM 20	River km 193	Not available**	Not available**
N. Sioux City, IA	LBSM21	River km 209	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum of 235 *E. coli* organisms/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Tables 3.79 and 3.80 show the maximum differences measured in both high (1% rank) and low flow (70% rank) conditions.

Table 3.79 BSRTMDL-5, High Flow (1% rank), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Westfield Creek, IA	LBSM19	Not available**	Not available**	Not available**
Broken Kettle Creek, IA	LBSM 20	Not available**	Not available**	Not available**
N. Sioux City, IA	LBSM21	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Table 3.80 BSRTMDL-5, Low Flow (70%), Departure from Capacity and Load Reductions Required

Monitoring site location	SDDENR site no.	Existing load *	Maximum allowable load *	% reduction required
Westfield Creek, IA	LBSM19	Not available**	Not available**	Not available**
Broken Kettle Creek, IA	LBSM 20	Not available**	Not available**	Not available**
N. Sioux City, IA	LBSM21	Not available**	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-5 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. Each feedlot in the South Dakota watershed was identified and evaluated. This information will eventually be included by SDDENR in a watershed model called Annualized AgNPS (Agriculture NPS) for the South Dakota Big Sioux watershed. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

<u>Iowa Pollutant Sources:</u>

The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from BSRTMDL-4, and non-point sources from the five HUC 12's that drain directly to this river segment.

Iowa Point Sources: There are no permitted wastewater treatment plants or animal feeding operation facilities in the BSRTMDL-5 sub-watershed.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.82 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.81 to 3.83 show the delivered loads for the various non-point sources for the five HUC 12's on the Iowa side that discharge into the BSRTMDL-5 segment.

Table 3.81 BSRTMDL-5, Livestock, wildlife and built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR**	June load* at BSR **	Oct. load * at BSR **
20	Upper Broken Kettle Cr.	19.71	4.74E+13	3.42E+13	3.06E+14
22	Bull Run	19.71	1.83E+13	1.33E+13	1.16E+14
23	Lower Broken Kettle Cr.	0	1.24E+13	6.40E+12	7.65E+13
24	Big Sioux River	0	2.40E+10	2.40E+10	2.81E+10
25	Big Sioux River	0	2.07E+13	1.57E+13	1.38E+14

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.82 BSRTMDL-5, Cattle in streams NPS loads

No.	HUC name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
20	Upper Broken Kettle Cr	252	19.71	8.05E+11	1.61E+12	8.05E+11
22	Bull Run	114	19.71	3.62E+11	7.25E+11	3.62E+11
23	Lower Broken Kettle Cr	17	0	1.32E+11	2.64E+11	1.32E+11
24	Big Sioux River	0	0	0.00E+00	0.00E+00	0.00E+00
25	Big Sioux River	20	0	1.53E+11	3.07E+11	1.53E+11

*Units for these loads are *E. coli* organisms/day. The percentages are the fraction of time that grazing cattle spend in the stream.

Table 3.83 BSRTMDL-5, Failing Septic systems NPS loads

No.	HUC 12 name	Failed septics	Distance to BSR, km	Load at BSR *
20	Upper Broken Kettle Creek	192	19.71	3.50E+09
22	Bull Run	86	19.71	1.57E+09
23	Lower Broken Kettle Creek	239	0	1.07E+10
24	Big Sioux River	120	0	5.36E+09
25	Big Sioux River	103	0	4.58E+09

*Units for these loads are *E. coli* organisms/day.

South Dakota Pollutant Sources

The South Dakota pollutant sources for this segment consist of the loads measured at Brule Creek near its confluence with the Big Sioux River, and the direct HUC 12 loads. Estimates of these loads will be made by SDDENR and put in Table 3.84 when available.

Table 3.84 BSRTMDL-5, South Dakota Pollutant Load Estimates

Pollutant Source	Location	SDDENR site no.	High flow (1%) load	Low flow (70%) load
Brule Creek	River km 165	LBST15	Not available**	Not available**
Direct HUC 12's	Incremental **	NA	Not available**	Not available**

*Units for these loads are *E. coli* organisms/day.
**South Dakota data analysis is not currently available.
***Loads to the BSR from adjoining HUC 12's are incrementally distributed along the BSR length by bacteria load per km.

3.9.2 Pollutant Allocations

Wasteload Allocation

There are no wastewater treatment plants or NPDES permitted animal feeding operations in the BSRTMDL-5 sub-watershed on the Iowa side of the River. Therefore, there are no wasteload allocations for this TMDL.

Load Allocations and Pollutant Load Reductions Needed

The load allocations for this TMDL are based on the discharges from the five Iowa HUC 12's that discharge to the BSRTMDL-5 segment, the loads from the South Dakota hydrologic units, tributary streams, and the BSRTMDL-4 segment of the Big Sioux River itself where it flows into the BSRTMDL-5 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the sample maximum water quality standard of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.85 through 3.88). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.85 BSRTMDL-5 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	4.36E+11	3.58E+13	98.8%
22	Bull Run	1.96E+11	1.41E+13	98.6%
23	Lower Broken Kettle Creek	5.44E+11	6.68E+12	91.9%
24	Big Sioux River	2.73E+11	2.94E+10	none
25	Big Sioux River	2.33E+11	1.61E+13	98.5%

*Units for these loads are *E. coli* organisms/day.

Table 3.86 BSRTMDL-5 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	8.83E+10	2.59E+12	96.6%
22	Bull Run	3.97E+10	1.11E+12	96.4%
23	Lower Broken Kettle Creek	1.10E+11	4.58E+11	75.9%
24	Big Sioux River	5.54E+10	6.05E+09	none
25	Big Sioux River	4.73E+10	7.61E+11	93.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.87 BSRTMDL-5 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	3.31E+10	1.71E+12	98.1%
22	Bull Run	1.49E+10	7.64E+11	98.1%
23	Lower Broken Kettle Creek	4.13E+10	2.93E+11	85.9%
24	Big Sioux River	2.08E+10	5.43E+09	none
25	Big Sioux River	1.77E+10	3.56E+11	95.0%

*Units for these loads are *E. coli* organisms/day.

Table 3.88 BSRTMDL-5 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	2.21E+10	1.62E+12	98.6%
22	Bull Run	9.93E+09	7.30E+11	98.6%
23	Lower Broken Kettle Creek	2.75E+10	2.77E+11	90.0%
24	Big Sioux River	1.38E+10	5.37E+09	none
25	Big Sioux River	1.18E+10	3.16E+11	96.3%

*Units for these loads are *E. coli* organisms/day.

3.10 Margin of Safety for All Five TMDLs

The Margin of Safety (MOS) for all five of the Big Sioux River TMDLs in this document is the same. The MOS is intended to provide a buffer for uncertainty in the load evaluations. The MOS consists of conservative assumptions implicit in the representation and modeling of non-point sources. These assumptions are:

- There is no die-off of bacteria originating in HUC 12's adjacent to the Big Sioux River or from the time of travel between the source within the sub-watershed and the HUC 12 discharge location.
- The water quality standard of a sample maximum of 235 E. coli org/100ml is used to evaluate all discharges to the Big Sioux River and that this criteria must be met without considering dilution.
- The maximum non-point source load as estimated by the Bacteria Indicator Tool spreadsheet is always available for washoff.
- Bacteria die-off in manure storage tanks and lagoons is not included in the load available for washoff calculations.

For point sources, i.e., wastewater treatment facilities, it is assumed that the facility will monitor discharges for compliance with the water quality standards and disinfect as needed. A margin of safety has not been applied to the wasteload allocations for the municipal wastewater treatment plants since they are required to meet the water quality standards at their discharge and to demonstrate this by monitoring, making the uncertainty of compliance very low.

3.11 Total Maximum Daily Load Calculation

The total maximum daily load for each of the five impaired Big Sioux River segments are the water quality standard sample maximum of 235 *E. coli* organisms/100 ml. The total maximum daily load equation is:

TMDL (allowable load) = WLA (point source loads) + LA (non-point source loads) - MOS (implicit reduction in the allocations to provide for uncertainty)

As noted in the margin of safety section, there is little uncertainty in the wasteload allocation calculations for the wastewater treatment plants in the watershed. The margin of safety reduction is implicitly applied to the non-point source load allocations. The TMDL equation then becomes:

TMDL = WLA + LA

For example, using a Load Allocation criteria of 235 *E. coli* org./100 ml at a given design flow the allocation is:

Load allocation = (design flow, liters/second)*(235 *E. coli* org./100ml)*
(10 deciliters/liter, conversion)

This method of calculating the Load Allocations for all non-point source loads in the 48 HUC 12 sub-watersheds includes all event driven non-point source, cattle in the stream, and failed septic tank loads. Event driven loads are runoff from livestock, wildlife, and built-up areas.

4. Implementation Plan

An implementation plan is not a required component of a TMDL document but is a useful and logical extension of TMDL development. Implementation plans provide IDNR staff, partners, and watershed stakeholders with insight into water quality problems and can point towards a strategy for improvement.

This strategy should guide the stakeholders and the IDNR in the development of a priority based watershed plan that will implement best management practices with the goal of improving the water quality of the Big Sioux River and meeting the TMDL targets.

The analysis and modeling of the Big Sioux River watershed shows that controlling livestock manure runoff and cattle in streams would need to be a large part of a plan to reduce bacteria. Best management practices include feedlot runoff control; fencing off livestock from streams; alternative livestock watering supply; and buffer strips along the river and tributary corridors to slow and divert runoff. In addition to these sources, failed septic tank systems need to be repaired and wastewater treatment plants need to control the bacteria in their effluent.

As noted in Section 2, open feedlots for cattle with a capacity of 1000 head or more are registered with IDNR. As part of an agreement with EPA, called the Iowa Plan for Open Feed Lots, these operations will be required to have complete runoff controls (to the 25 year, 24 hour storm) or reduce their operations to under 1000 head in 2006. There are currently 38 registered open feedlots in the Iowa part of the Big Sioux and Rock River watersheds. As part of an implementation plan the department can see how many of these plan on implementing run-off controls and how many will be reducing below 1000 head. This is a high level of control and it should be possible, with adequate monitoring, to see improvements in water quality downstream of these feedlots. Since feedlots can have major impacts these changes may provide significant pollutant reductions.

It would be useful to create a local watershed advisory committee that could identify high priority areas within the Big Sioux River watershed where resources can be concentrated for the greatest effect. The areas with greatest impact on the river are adjacent to streams. In addition, priority best management practices should be identified for implementation. Since the impairment problem occurs at almost all flow conditions, solutions will need to be implemented for non-point sources with event driven transport, non-point sources that behave like continuous sources such as cattle in streams and failed septic tank systems, and continuous point sources such as wastewater treatment plants.

5. Monitoring

Monitoring of the Big Sioux River mainstem will continue to be done by SDDENR at their four historical ambient sites. This program operates four monitoring sites on the Iowa reach of the Big Sioux River, at Canton, Hudson, Alcester and Richland, South Dakota. Data collected at these four sites is used by the IDNR for its biannual water quality assessments (305b report) of the Big Sioux River. IDNR will continue monthly Rock River ambient monitoring at the site near Hawarden.

Due to resource limitations, there are not any plans to continue targeted TMDL monitoring of the mainstem BSR, Rock River, or other tributaries. The existing ambient monitoring being done by South Dakota and Iowa provides only minimal information for water quality assessment and evaluation of the effectiveness of watershed best management practices. To really understand the Big Sioux River pollutant problems and effectively manage their impact through improvements to controls, additional targeted monitoring is needed.

Phasing TMDLs is an iterative approach to managing water quality that is used when the origin, nature and sources of water quality impairments are not completely understood. In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the resources and information available.

These five TMDLs represent Phase 1 in the development of a project to improve Big Sioux River water quality. The value of these evaluations and the effectiveness of their follow-ups are dependent on local activities to improve conditions in the watershed. Without the efforts of watershed citizens, implementation of practices that will remedy the Big Sioux River impairment may not occur. What is needed in a second phase are stakeholder driven solutions and more effective management practices. Continuing targeted monitoring will determine what management practices result in load reductions and the attainment of water quality standards. Summarizing, renewed targeted monitoring will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

The first phase of the Big Sioux River watershed improvement plan is contained in these five TMDLs that set specific and quantified targets for pathogen indicator concentrations in the river and allocate allowable loads to all sources. An effective Phase 2 will require the participation of the watershed stakeholders in the implementation of pollutant controls and continued water quality evaluation. This will require continued targeted monitoring, thorough appraisal of the collected data, the readjustment of allocations, and the modification of management practices as shown to be necessary.

6. Public Participation

The department has put together and implemented a plan to inform the public and stakeholders and get input and response for Big Sioux watershed TMDL project reports and activities. The plan has included three public meetings held in June 2005 at three locations in the Big Sioux River watershed. Two other meetings that included discussion of the Big Sioux TMDL took place at meetings of the Plymouth and Lyon County Soil and Water Conservation Districts (SWCD).

The dates and locations of the public meetings were:

June 17, 2005 West Lyon Comm. Sch., City of Inwood, Lyon County. (8 attendees)
June 21, 2005 City of Hawarden, Plymouth County (8 attendees)
June 21, 2005 City of Sioux Center, Sioux County (13 attendees)

The public and stakeholders attending these meetings included farmers, livestock producers, county conservation staff, municipal staff, engineering consultants, bankers, Natural Resource and Conservation Service (NRCS) staff, reporters, county public health staff, and university students. Comments received at these public meetings were noted, summarized, and have been and continue to be reviewed and considered.

The dates and locations of the other two stakeholder meetings were:

June 23, 2005 Plymouth County SWCD Focus Meeting, Le Mars (9 participants)
June 28, 2005 Lyon County SWCD Focus Meeting, Rock Rapids (11 participants)

The Plymouth County meeting included SWCD commissioners, representatives of the Pork Producers, the Plymouth County Cattlemen’s Association, rural water associations, and NRCS. The Lyon County meeting included SWCD commissioners, representatives of the Cattlemen’s Association, rural water associations, landowners and livestock operators. The water quality problems in the watershed were discussed at length in these meetings and comments made have been considered during the development of this document.

A second series of public and stakeholder meetings will be held in the watershed with the release of this draft TMDL. The purpose of these meetings is to provide information related to the draft TMDL and to obtain public and stakeholder input and comment on TMDL development and conclusions. Comments received will be reviewed and given consideration and, where appropriate, incorporated into the TMDL.

7. References

IAC. 2004. Chapter 567-61: water quality standards. Iowa Administrative Code [effective date 6/16/04].

Novotny and Chesters. 1981. Handbook of Nonpoint Pollution Sources and Management.

Tollner, Ernest W. 2002. Natural Resources Engineering.

USEPA. 2001. EPA 841-R-00-002. Protocol for Developing Pathogen TMDLs, First Edition.

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Appendix A – List of Available E-files

The first part of this list of electronic spreadsheets, maps, and GIS coverages consists of fourteen spreadsheets that include most of the key data and analysis used in the development of this TMDL report. These spreadsheets and the procedures and assumptions in them are documented and described in detail in Appendix B, Procedures and Assumptions. They are accessible using widely available spreadsheet software and can usually be distributed by email.

The second part of the list includes spreadsheets that are not as well documented and explained and which are more peripheral to TMDL analysis and development; maps of the watershed and streams including monitoring sites; information such as duration curves and monitoring data in less accessible formats such as the hydrograph software used in the project autosamplers; and ArcView GIS coverages (Other Development E-files section).

Key Data and Analysis Spreadsheets

1. BSR direct BIT.xls – This spreadsheet distributes non-point source bacteria loads by the 25 BSR directly draining HUC 12's and by the month of the year.

2. Rock BIT.xls - This spreadsheet distributes non-point source bacteria loads by the 23 Rock River HUC 12's and by the month of the year.

3. BSR direct delivery.xls – Non-point source load delivery estimates for the BSR directly draining HUC 12's. Includes bacteria die off calculations.

4. Rock delivery.xls - Non-point source load delivery estimates for the Rock River HUC 12's. Includes bacteria die off calculations.

5. Mud Creek Time of Travel.xls – Estimated time of travel for design flows from the Iowa/Minnesota border to the BSR.

6. Rock River Time of Travel.xls - Estimated time of travel for design flows from the Iowa/Minnesota border to the BSR.

7. Little Rock River Time of Travel.xls - Estimated time of travel for design flows from the Iowa/Minnesota border to the BSR.

8. Rock River data.xls – Rock River monitoring data and tributary design flow estimates.

9. BSR direct wwtp.xls – This spreadsheet includes the calculations for the development of the WLA's for the wastewater treatment facilities in the BSR directly draining watershed.

10. Rock wwtp.xls - This spreadsheet includes the calculations for the development of the WLA's for the wastewater treatment facilities in the Rock River watershed.

11. MN allocations.xls – Calculations of the load allocations for the Minnesota part of the Rock River watershed.

12. Stream data analysis.xls – This spreadsheet includes the data and analysis of the four streams monitored streams used to develop delivery ratios and design flow conditions for bacteria loads.

13. BSR direct allocations and reductions.xls – Calculation of the BSR directly draining HUC 12 allocations, existing loads, and reductions needed.

14. Rock allocations and reductions.xls - Calculation of the Rock River HUC 12 allocations, existing loads, and reductions needed.

Other Development E-files

- BSMaps *folder*- Contains maps of the entire BSR watershed, the Iowa targeted TMDL monitoring sites, and the SD DENR mainstem and tributary monitoring sites.

- Hydrographs *folder* – Contains hydrographs from the 7 autosamplers for 2002 and 2003 as well as concentration data and charts of measured concentration vs. flow.

- Loading Rates *folder* – Contains event data and flow estimates, both daily and hourly for each auto-sampler site.

- Source inventory *folder* – Estimates of source locations and load quantification.
    - BSR direct livestock distribution by huc 12.xls – This is where the distribution of livestock by type and HUC 12 is made.
    - County deer population est2004.xls – Deer population estimates by county.
    - lyonpop.xls – Census blocks for Lyon County. Used to estimate septic tank numbers.

- o plymouthpop.xls – Census blocks for Plymouth County. Used to estimate septic tank numbers.
- o siouxpop.xls – Census blocks for Sioux County. Used to estimate septic tank numbers.

- o RV gage characteristics.xls – USGS gage data used to calibrate and check estimates.

ArcView GIS *folder* – This folder contains ArcView project and theme files showing the digitized streams, elevation changes, HUC 12's, HUC 12 discharge locations, wastewater treatment plants, impaired river segments, and tables of distances. ArcView 3.2 is required to view these folders.

Big Sioux River Model Project – There are three Views in this Arcview project and several layout maps. The three views are BSR model, Rock model, and NPS loads. The BSR model includes the Big Sioux River layout and themes and the direct discharge HUC 12's, SD DENR mainstem monitoring sites, stream elevations, model kilometer markers, land uses, clipped census blocks by county for septic tank evaluation, wastewater treatment plant locations, and river and tributary lengths. The Rock River model includes all of the same types of coverages that the BSR model has only for the Rock River. The Rock River model also includes distances, elevations and slope, model kilometer markers, and locations of HUC 12 discharges for the two main tributaries from Minnesota, Mud Creek and the Little Rock River. The NPS load view includes both the Rock River and BSR direct discharging HUC 12's and the locations of registered animal feeding operations.

TMDL 1 Project – Contains spatial information and tables showing the impaired TMDL 1 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 2 Project – Contains spatial information and tables showing the impaired TMDL 2 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 3 Project – Contains spatial information and tables showing the impaired TMDL 3 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 4 Project – Contains spatial information and tables showing the impaired TMDL 4 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 5 Project- Contains spatial information and tables showing the impaired TMDL 5 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

Appendix B, Procedures and Assumptions

This appendix consists of a sequential guide to the spreadsheets and procedures used in the development of the Big Sioux River bacteria TMDLs. It begins with an evaluation of the bacteria sources and ends with load allocations and reductions needed.

E. coli and Fecal Coliform Pathogen Indicator Bacteria

The 2002 305(b) water quality assessment, the basis for the impaired listing of the Big Sioux River segments, used fecal coliform as pathogen indicator bacteria since this was the water quality standard at the time. Then, effective July 17, 2003, another pathogen indicator bacteria, E. coli, replaced fecal coliform in the Iowa water quality standards. *E. coli* are a subset of fecal coliform bacteria and research has indicated that *E. coli* are a better indicator of fecal contamination by warm-blooded animals.

This TMDL report has been developed during the period of transition from one standard to the other. Since there is currently no EPA approved analytical method for measuring *E. coli*, an equivalent *E. coli* to fecal coliform conversion has been used that is based on comparable risk of illness for primary recreational contact rather than an organism-to-organism ratio. The equivalent fecal coliform values are calculated based on an *E. coli* to fecal coliform comparable risk ratio of 1 to 1.6.

Table B.1 *E. coli* to fecal coliform risk ratio

E. coli **(organisms/100ml)**	**Fecal Coliform (organisms/100ml)**
126	202
235	376
630	1008
2880	4608

The effects that this transition has had on the development and writing of this document are:

- References for fecal coliform loads from various sources are more available and tested than those for *E. coli.*
- Die-off calculations have been performed using fecal coliform since many of the equations were developed for them.
- The maximum E. coli value that is available in the SDENR data is 2,420-organisms/100 ml, in bacterial terms a fairly small number. During events the fecal coliform counts go into the millions. This means that a relationship between flow and E. coli cannot be established and the more reliable fecal coliform measure needs to be used for this purpose.
- For consistency, to avoid confusion, and because the new water quality standards use E. coli, nearly all pathogen indicator values in the TMDL

document itself are expressed as E. coli organisms/100 ml although this has required the frequent translation of fecal coliform to E. coli.

- Most of the spreadsheets used in the development of the TMDLs use fecal coliform that is translated to E. coli as a last step before being incorporated into the main document.

The Modified EPA Bacteria Indicator Tool (BIT); Inventorying and Estimating Non-point Source Bacteria Loads

There are two spreadsheets used to develop the non-point source loads to the Big Sioux River, *BSRdirectBIT.xls* and *RockBIT.xls* that are based on the EPA Bacteria Indicator Tool. This tool was designed to provide input to the Hydrological Simulation Program FORTRAN (HSPF) for non-point source bacteria loads. For this report, it has been modified by the IDNR in two separate spreadsheets to estimate fecal coliform loads available for washoff from each of the 23 twelve digit HUCs in the Iowa Rock River watershed and the 25 twelve digit HUCs in Iowa that directly drain to the Big Sioux River (BSR). The loads are input to a straightforward hydrologic model based on the Manning equation and HSPF is not used.

The animal numbers have been spatially distributed to the 23 Rock River and 25 BSR direct HUC 12's using GIS methods developed by IDNR. This method incorporates CAFO and AFO registration and permitting data bases, surveys of buildings and feedlots using aerial infrared photography done in 2002, and livestock statistics and numbers from county by county counts.

The landuse information comes from 2002 IDNR coverages that have been consolidated into the four landuses found in this spreadsheet. A number of modifications have been made to the original EPA worksheets and some additional worksheets have been added to accommodate the needs of the project. The assumptions about the distribution and timing of manure application have been made based on advice from Iowa Department of Agriculture and Land Stewardship (IDALS) staff, IDNR field and central office staff, and locally based field assessments. These assumptions will be reviewed and adjustments made as better information becomes available for follow-up phases of this project. Notes on assumptions and references can also be found in the individual worksheets.

There are three worksheets in each of the BIT spreadsheets that provide loading input for evaluation of non-point source loads. These worksheets are named 'cattle in stream', 'septics', and 'total loads'.

The first two, 'cattle in streams' and 'septics', are used to estimate loads from sources that are assumed to be constant through the times that they are significant. For cattle in streams, this includes the grazing season, from April to November, and adjusts by the month, i.e., cattle spend more time in the stream during the warmer months. For failed septic tank systems, the loads are assumed to be continual and steady. In both the ‘cattle in streams’ and ‘septics’ worksheets the bacteria load die-off has been estimated from the time of travel and die-off rate for each of the 23 Rock River HUC 12s and 25 Big Sioux River direct HUC 12’s.

The third worksheet (‘total loads’) sums up the maximum fecal coliform load available for “wash-off” during a precipitation event for each month of the year. This represents the potential for non-point source loads. There are four land use categories in the BIT spreadsheets that are consolidations of the 16-landuse types in the IDNR GIS coverages. The land use categories are:

- Cropland – includes the alfalfa, corn, soybean, and “other rowcrop” land use types.
- Grazed pastureland – includes only grazed grassland landuse. It is assumed that all grazing cattle manure except that from cattle in streams is deposited on this type.
- Forest and ungrazed pastureland – Includes three types of forest; bottomland, coniferous, and deciduous; and two types of pasture, ungrazed grasslands and CRP grasslands. It is assumed that the only fecal coliform loads to this category are from wildlife.
- Built-up areas – Includes roads, commercial/industrial, and residential categories. These three types are used in the Built-up worksheet to estimate loads.

In the worksheets for the four land use categories the total bacteria accumulation from wildlife and the different livestock types is estimated month by month. The maximum number of fecal coliform organisms that is available for washoff is 1.5 times the maximum daily accumulation in the warm months (April to September) and 1.8 in the colder months (October to March). The total loads by landuse and HUC 12 are calculated in the worksheet ‘HUC 12 monthly total loads’. The maximum loads from the four landuses are summed in the ‘total loads’ worksheet by HUC 12 and then by month of the year.

All of the HUC 12 total fecal coliform daily loads from the BIT spreadsheets for the months of April, June, and October are input into the spreadsheets *Rock delivery.xls* and *BSR direct delivery.xls*. In these spreadsheets the delivered load, accounting for time of travel die-off and the delivery ratio, is calculated. The resulting delivered loads from each HUC 12 for April, June, and October are found in the report tables for each TMDL labeled *Livestock, wildlife and built-up area event NPS loads*. April and October are months when manure application is usually at its maximum and June is a month when there are high manure application rates, maximum numbers of cattle in the stream, and the month when most precipitation events were monitored. Only the highest delivery ratio, 35%, is used for the months of April and October in these worksheets. For the month of June, all four of the delivery ratios, 35%, 1%, 0.1%, and 0.01%, were used because June is the design period for load allocations and reductions.

Time of travel, bacteria die-off, delivery ratios, and load allocations and reductions are described in the following sections.

Estimating Time of Travel

The time of travel from the bacteria sources to the Big Sioux River is an important value in the calculation of bacteria die-off. It is used to estimate bacteria die-off that occurs from each of the wastewater treatment plants, HUC 12 discharge locations, and loads from the three Minnesota streams contributing to the Rock River watershed.

The length of the streams tributary to the Big Sioux River has been measured and digitized using IDNR one meter resolution infrared aerial photography and USGS 7.5 minute topographic map GIS coverages. A system of kilometer markers has been laid over the digitized streams, as have the 10-foot contour elevations from the USGS 7.5 minute maps. The length of the segments between contours and the change in elevation has been used to calculate the average slope between contour lines. Figure B.1 shows an example of the way the Rock River watershed streams have been laid out where Mud Creek and the Little Rock River flow into the mainstem Rock River.

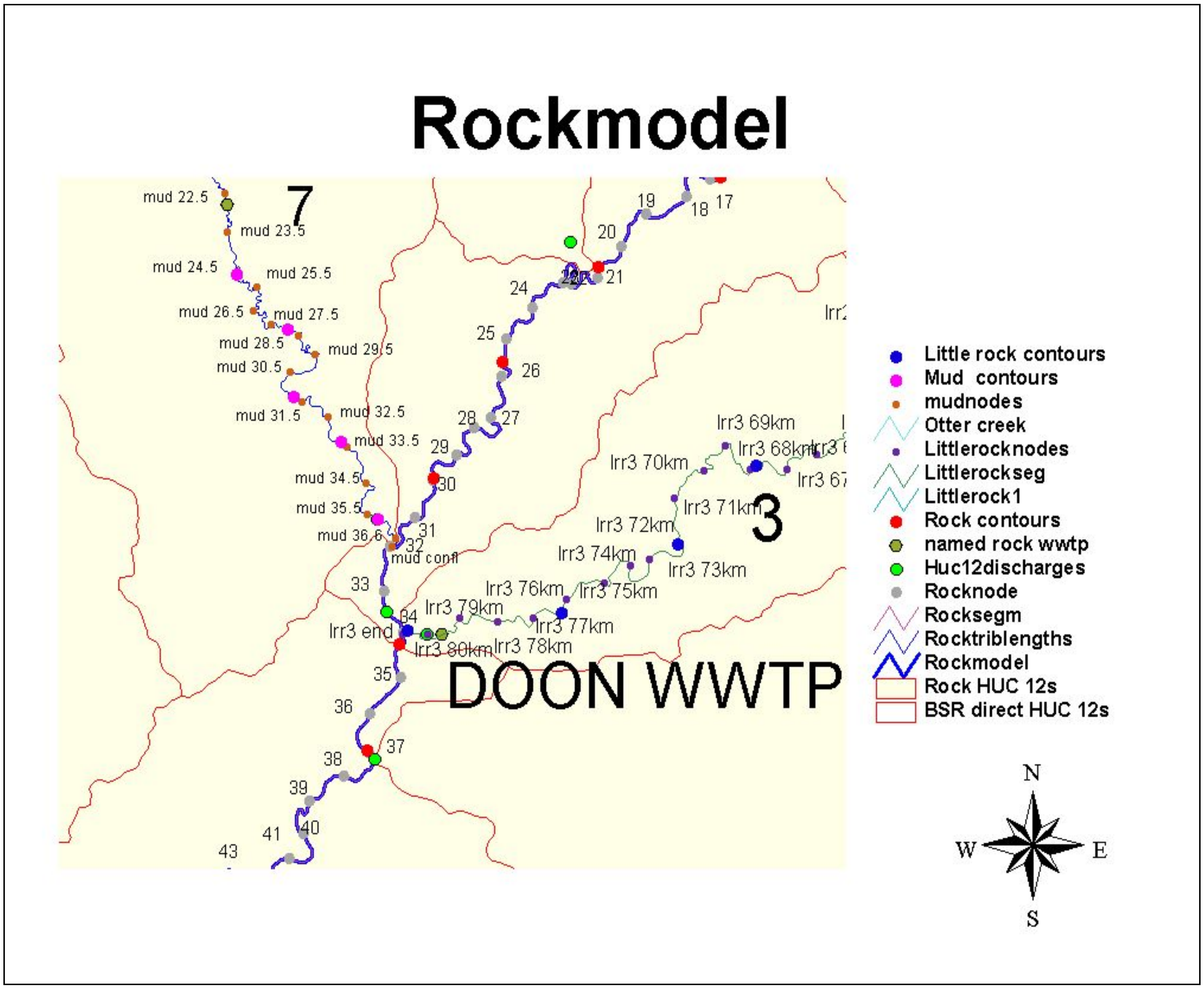

Figure B.1 Layout example

For each segment between contours the Manning equation is applied to estimate the time of travel as shown here.

Solve for:
d = mean depth = hydraulic radius, meters
A= x-section area, m^2
v = stream velocity, meters/second
ToT = time of travel, seconds or hours or days

$$Q = \left(\sqrt{S/n}\right)(w)\left(d^{5/3}\right)$$
$$d = \left[Q\left(n/\sqrt{S}\right)(1/w)\right]^{(3/5)}$$
$$A = w * d$$
$$v = Q/A$$
$$ToT = v/L$$

<u>Known</u>
Q = flow, m^3/s
S = slope, meter/meter
n, roughness, unitless
W = channel width, meter
L = segment length, km

The bank-to-bank width for each slope segment has been estimated by taking several measurements from the aerial photography coverage taking care to avoid sand bars, cut banks, and tree covered areas. These measurements are then averaged for each segment (see the 'width' worksheets in the Mud creek, Rock River, and Little Rock River time of travel spreadsheets). The channel roughness is obtained from standard tables and adjusted upwards as the calculations move upstream, i.e., the smaller a stream gets the higher the roughness factor. The range used is from 0.035 to 0.045 depending on the stream size.

The stream flow for Mud Creek, Rock River, and the Little Rock River have been estimated for three design conditions based on data collected during and after precipitation events and at regular monthly intervals in 2002 and 2003. The monitoring sites for Mud Creek and the Little Rock River were where the streams crossed from Minnesota into Iowa and where they flowed into the Rock River. Auto-samplers with continuous flow estimating were used at the confluences of Mud Creek and the Little Rock River with the Rock River. The Rock River was monitored where it crossed into Iowa, at the Rock Rapids USGS gage, and at the Rock Valley USGS gage.

Event flows and concentrations were used to estimate the high flow conditions. These events were infrequent but the measured flows were significantly higher than the typical monthly measurements. The high flows at the border for each stream were matched against the high flows at the confluence with the Rock, or, in the case of the Rock River itself, the flows at the border were matched against the Rock Rapids and Rock Valley USGS gages. The flow estimates for the three design conditions can found in the *Rock River Data.xls* spreadsheet. The monitoring site numbers in the spreadsheet match those on the Figure 3 site map.

The difference between the upstream flow at the border of each stream and the larger flow at the downstream sampling site is added equally to each kilometer of stream length between the two sites. The flow added to each slope segment is added based on its length. A segment 2.5 km long and with an incremental flow increase of 2 cfs per km would have a flow equal to the segment upstream of it plus 5 cfs (2 cfs/km*2.5 km). This segment flow then becomes the upstream flow to the next slope segment and the incremental flow is then added to it and so on down stream.

For the Little Rock River, a large tributary, Otter Creek, was not monitored. The flow for this stream was estimated by land area proportional to the land area of the watershed that was monitored. This flow was introduced into the Little Rock River slope segment at its confluence with Otter Creek. The flow calculations for the individual stream slope segments are in the 'high flow', 'low flow' and 'very low flow' worksheets in the Time of Travel spreadsheets for each of the streams. These worksheets also contain specific references to the data used from the *Rock River Data.xls* spreadsheet.

There is another worksheet in *Rock River Data.xls* called ‘hydrocheck’ that has been used to do a water balance between the flows measured in Mud Creek, mainstem Rock River, and the Little Rock River and the flows measured at the Rock Valley USGS gage. The total of the three upstream flows should equal the flow at the Rock Valley gage for the same time period. Twelve sets of data for the three-stream total and the Rock Valley gage were regressed and the r-squared was 0.992, a very good correlation. Some of the data was not included in the regression because there was missing flow data for one of the three streams or field notes indicated that there had been a problem with the ISCO samplers on the day of interest.

Making the assumption that the hydraulic radius is the same as the average depth for channels that are much wider than they are deep, enough information is available to solve the Manning equation for mean depth (d). From this the cross-sectional area (A), velocity (v), and time of travel (ToT) can be estimated for each individual slope segment. Adding the individual slope segments’ time of travel together gives the total time of travel for the entire stream reach.

Direct time of travel estimates as described above were made for the entire length of the Iowa reaches of the Rock River, the Little Rock River, and Mud Creek at each of the three flow conditions; high, low, and very low all the way to the confluence with the Big Sioux River. The Rock River watershed wasteload allocations for wastewater treatment plants and the load allocations for Minnesota used these times of travel to estimate die-off from the discharge location to the Big Sioux River.

For the Rock River HUC 12 discharges, including non-point source event run-off and for the continuous non-point sources - cattle in stream and failed septic tank systems - time of travel estimates were made using velocity averages for the lengths of Mud Creek (high = 0.495 m/s, low = 0.245 m/s, very low = 0.127 m/s) and the Rock River (high = 0.747 m/s, low = 0.438 m/s, very low = 0.315 m/s) at the three flow conditions.

For the wastewater treatment plants and the non-point sources in the HUC 12s that discharge directly to the Big Sioux River, the Mud Creek time of travel and velocity averages were used since Mud Creek was most like the streams draining these sub-watersheds.

Estimating Bacteria Die-off

Fecal coliform bacteria die-off between the source and the Big Sioux River was estimated using the time of travel as calculated above and a decay coefficient in the standard exponential equation used for this purpose. The equation is:

$$C_x = C_o / e^{kt}$$

Where: **Co** = Initial bacteria count, as a concentration of organisms per 100 milliliters or liters or as a daily load, organisms per day immediately below the discharge.

$\mathbf{C_x}$ = Concentration or daily load at a point distance "x" downstream of the discharge.

k = first order decay coefficient, 1/day

t = time of travel, days

This form of the equation is used to estimate the fecal coliform loads delivered to the Big Sioux River. To estimate the allocations to a source that is some distance from the impaired river segment the following equation form is used:

$$C_o = C_x e^{k*t}$$

Where: $\mathbf{C_o}$ is the allocation at the discharge location taking into account the decay that will take place before the load gets to the impaired stream.

The first order decay coefficient used throughout the die-off calculations used for the Big Sioux TMDLs is 0.96 per day. This is the median coliform disappearance rate from 30 in-situ studies described in the EPA document *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling* (2nd edition) EPA/600/3-85/040.

Time of travel and bacteria decay is incorporated in the two loading spreadsheets, *Rock BIT.xls* and *BSR direct BIT.xls*, in the cattle in streams and septic tank worksheets; in the two delivery spreadsheets associated with the loading spreadsheets, *Rock delivery.xls* and *BSR direct delivery.xls*; the wastewater treatment plant wasteload allocations spreadsheets, *Rock wwtp.xls* and *BSR direct wwtp.xls*; and the Minnesota loads and allocations spreadsheet called *MN allocations.xls*.

Bacteria die-off can be a big factor for sources that are a good distance from the Big Sioux River, especially in low flow conditions when velocity decreases and time of travel increases. The load allocations for the three streams that cross from Minnesota show this in that there are load allocations at high flow but none at low or very low flows.

Estimating Delivery Ratios and Design Flow Conditions

Delivery ratios as used in these load and allocation calculations are the ratio of the load measured in the stream by monitoring and the load at the sources as estimated with the modified EPA Bacteria Indicator Tool spreadsheets. Four streams draining nine HUC 12's were monitored for two years by auto-samplers located near their confluences with the Big Sioux River. The data collected included event samples, monthly samples, and continuous flow. These streams were Sixmile Creek, draining three HUC 12's, Indian Creek draining two HUC 12's, Westfield Creek draining one HUC 12, and Broken Kettle Creek draining three HUC 12's.

The delivery ratios are affected by assumptions made in the loading worksheets for the nine HUC 12's in the watersheds of these streams as well as the relatively short time (two years) that targeted monitoring was done. The delivery ratios are used only to estimate the fraction of the non-point source loads that need a precipitation event to have an impact. The ratio is the percentage of the maximum load that is estimated to be available based on livestock and wildlife manure in croplands, pasture, and forest and runoff from built-up areas. It is assumed that some fraction (the delivery ratio) of the entire load from each HUC 12 is delivered to the HUC 12 discharge location.

There are two spreadsheets that include calculations for approximating a delivery ratio and estimating the design flow conditions. These are the *stream data analysis.xls* and the *BSR direct allocations and reductions.xls* spreadsheets. The *stream data analysis.xls* spreadsheet contains three worksheets for each of the four monitored streams:

- '(stream name) data' - These worksheets consist of the monitored flow and concentration data from the autosamplers sited near to where the streams flow into the Big Sioux River. The samplers were installed in 2002 and 2003 to collect continuous flow data and concentration data during precipitation events when the stream flows increased significantly. The data has required analysis and review to match the event concentration data with the correct flow. It was found that daily average flow did not represent the flow for a given event sample's concentration. By going back to the hydrograph and matching the time sample bottles used in the composite event sampling were taken to the hourly flow, it was found that the correlation between flow and concentration was greatly improved. This was especially true for event data.

The r-squared for a regression of the Sixmile Creek 2002 event data when hourly values are used is 0.833. There are three flow values for the event data that were evaluated,

1. The instantaneous flow and grab sample concentration taken when the samples were collected. This may or may not represent event related conditions depending on how elevated the stream flow is at the time.

2. The average daily flow of the stream calculated from the auto-sampler hydrograph. This flow value often does not accurately portray the real flow conditions when an event sample is taken by the auto-sampler, particularly for the four rather flashy small streams monitored.

3. The hourly flow from the auto-sampler hydrograph that could be matched to the time that specific sampler bottles were filled. As noted above, using this flow much improved the correlation between flow and concentration.

The evaluated data from these worksheets is used in the flow worksheets to provide data for flow and load duration curves and for the regression equations relating flow and concentration.

- '(stream name) flow' – The flow worksheets include all of the 2002 and 2003 average daily flow data for each of the four monitored streams as well as the evaluated flow and concentration data from the data worksheet. The flow data approximates the recreational use season when the auto-samplers were installed, April through November.

  The daily flow data is used to generate the flow and load duration curves found in these worksheets. The flow and concentration data from the data worksheet is plotted against the TMDL target load on the load duration curve. Multiplying the daily flow values times the target concentration of 235 E. coli org/100 ml converted to a daily load and plotting it as a percent load recurrence generates the curve representing the target load as shown in Figure B.2. By examining the load duration curve the hydrological conditions where the water quality problem occurs can often be determined. If the problem occurs at higher flows then it is likely caused by non-point source run-off and if it is occurring at lower flows then the problem is related to continuous point sources such as wastewater treatment plants. The load duration curves for the four streams tributary show that the target concentration (converted to a daily load) is exceeded through almost all flow conditions.

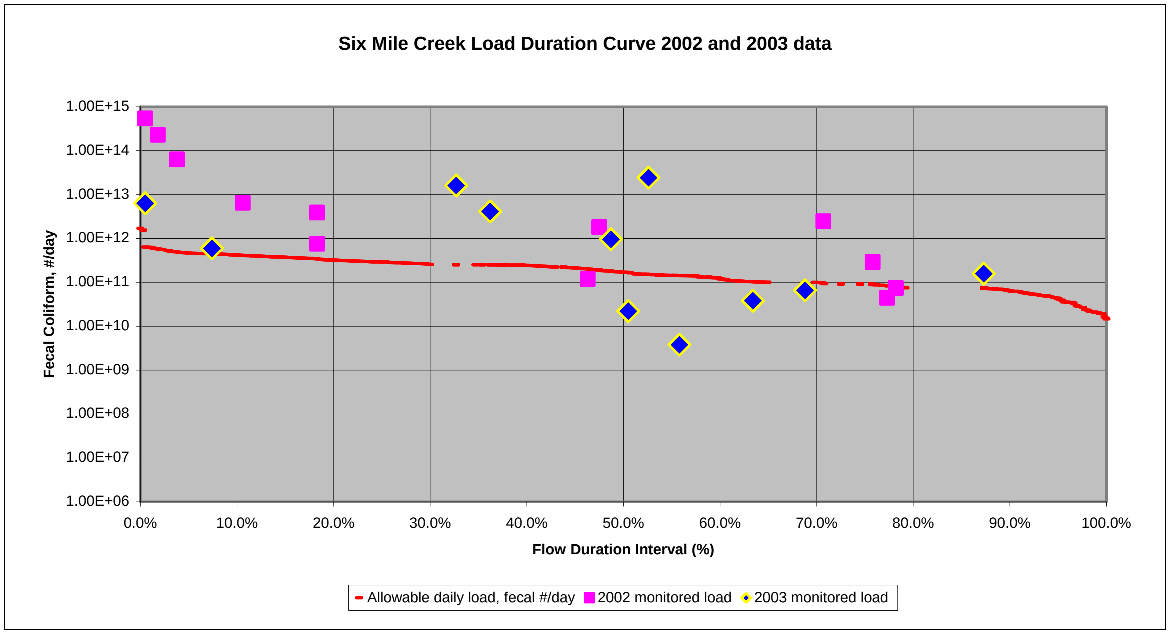

Figure B.2 Sixmile Creek Load Duration Curve

Often what is done to evaluate a load duration curve is to divide it into flow conditions. For example, EPA's Bruce Cleland, who has studied the use of load duration curves and their application to TMDL's, divides them in to five flow regions, 0-10% = high flows, 10-40% = moist conditions, 40-60% = mid-range flow, 60-90% = dry conditions, and 90-100% = low flows. The median of the monitoring data for each of these flow zones is then plotted along with the data points themselves.

Typically the flow duration curve, from which the load duration curve is derived, is based on data from a USGS gage and there are several years of daily flow data available. The flow duration curves for these four streams are based on flow data from only two years. This means that there is a chance that the ends of the flow duration curve, the highest and lowest flows, are not included.

For these TMDL's, where the bacteria water quality problems occur across most of the flow ranges, four flow duration rank conditions have been used. These are the 1%, 10%, 50%, and 70% flows. The 1% rank captures the impacts of significant run-off events and the 10%, 50%, and 70% ranks describe the continuum of decreasing concentrations from run-off and the increasing impacts from continuous sources such as cattle in the streams, failed septic tank systems, and wastewater treatment plants.

The evaluated flow and concentration data is also used in this worksheet to define the relationship between flow and concentration. This relationship is estimated using a non-linear power regression equation. Bacteria data from a mix of event and monthly monitoring typically does not show a linear relationship between flow and concentration and the Big Sioux monitoring data is no exception. At lower flows when the loads are from continuous sources and there are not any loads from run-off, the concentration and flow remain in a constant relationship. At higher flows when run-off from livestock and wildlife manure is the biggest factor, the bacteria concentrations rise very rapidly, usually more rapidly than the hydrograph. This is why power equations are used here to describe the relationship between flow and concentration.

Finally, the flow at the four flow percentile ranks, 1%, 10%, 50%, and 70% has been calculated for each of the four monitored streams. The regression equation is then used to estimate the bacteria concentration for the flow at the four ranks. A chart of the data and the flow/concentration regression equation for the Sixmile Creek monitoring is shown in Figure B.3. Table B.1 shows the flow for the design percentile flow ranks and the bacteria concentration calculated for each flow using the regression equation.

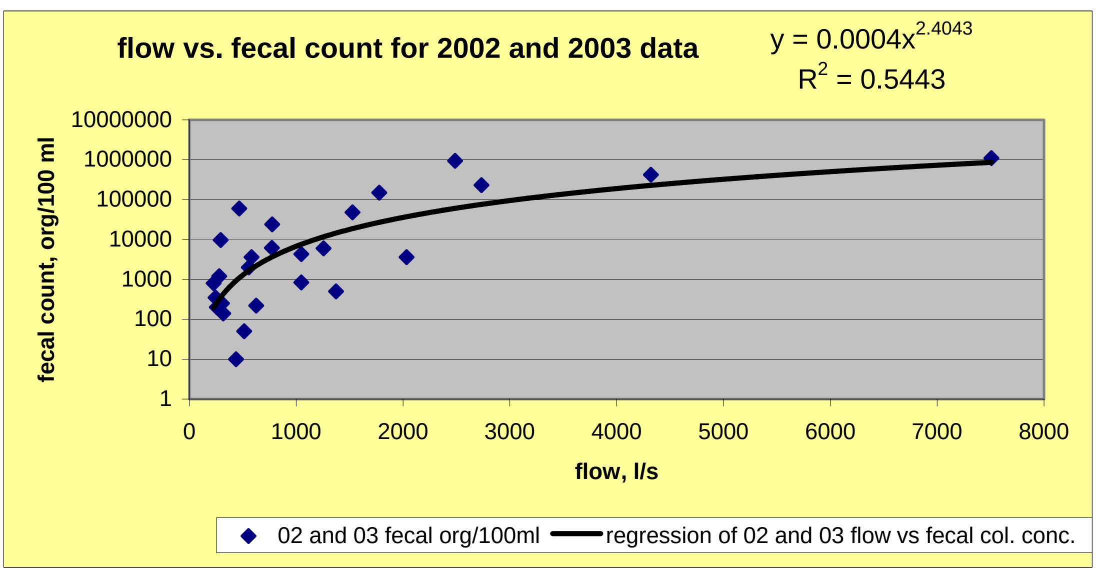

Figure B.3 Sixmile Creek data regression, flow vs. concentration

Table B.2 Application of the regression equation to the Sixmile Creek flow percentile ranks

flow duration percentile	design flow, l/s	fecal col. org./100 ml
0.1 percentile	5020	316010
1 percentile	1916	31193
10th percentile	1285	11943
50th percentile	521	1359
70th percentile	304	373
80th percentile	228	187

The flows at the percentile ranks and the associated bacteria concentrations are used in the loading worksheet to calculate the non-point source delivery ratio.

- '(stream name) loads' – This worksheet estimates the delivery ratio for each of the four monitored streams at each of the four design flow condition ranks (1%, 10%, 50%, and 70%). This involves converting the design flows from liters per second to liters per day and the associated fecal coliform concentrations from organisms per 100 milliliters to organisms per day based on the daily flow. The non-point loads for the HUC 12's in the watersheds of the monitored streams were added together for each and this became the available run-off load for the whole stream watershed from these sources.

  For the purposes of figuring the delivery at the decreasing flow rank discharge values, it has been assumed that the entire load for the concentration associated with the discharge is from non-point source run-off. This means that the fraction of the watershed load delivered drops a lot as the flow and concentration of bacteria in that flow decreases. This makes sense because runoff should hardly be a factor when the precipitation transport mechanism is no longer available. Table B.2 shows the delivery ratio estimate for the four flow ranks for Sixmile Creek where the total fecal coliform load for the three HUC 12's in this watershed has been estimated to be 2.90 E+15 org/day.

Table B.3 Sixmile Creek NPS delivery ratio estimate

Design flow duration, %	Design flow at interval, l/d	Existing load estimate at design flow, fecal col. org/day	Existing NPS load est. for the watershed, fecal col. org/day	Delivery ratio, June loading estimate, %
0.1 percentile	4.34E+08	1.37E+15	2.90 E+15	29.5%
1 percentile	1.66E+08	5.16E+13	2.90 E+15	1.1%
10th percentile	1.11E+08	1.33E+13	2.90 E+15	0.3%
50th percentile	4.50E+07	6.11E+11	2.90 E+15	0.01%
70th percentile	2.63E+07	9.81E+10	2.90 E+15	0.002%

The delivery ratios for the watersheds were variable at the design flow conditions. Westfield Creek is an anomaly because its watershed is a large HUC 12 whose landuse is mostly cropland but which received a fairly small number of cattle and other livestock in the distribution. The monitoring data shows a large run-off event bacteria load but the BIT spreadsheet estimates a small load available for washoff because there are few animals. What is going on here is that manure from other HUC 12's is being applied to the cropland in the Westfield Creek watershed or the livestock distribution is not accurate for this HUC 12.

The estimated delivery ratios and flows at the design percentile rank are used in the nonpoint source load allocations and reductions spreadsheet.

Estimating Load Allocations and Reductions

There are two spreadsheets that include the calculations for the load allocations and the load reductions needed for the Iowa parts of the Rock and Big Sioux River watersheds. These spreadsheets are called *BSR direct allocations and reductions.xls* and *Rock allocations and reductions.xls*. The delivery ratio for the Iowa part of the Big Sioux and Rock HUC 12 sub-watersheds is derived in the worksheet called 'delivery ratios'. The areal flow for each of the design flow conditions based on the HUC 12 area is also derived on this worksheet.

The delivery ratios for the four design flow rank conditions, 1%, 10%, 50%, and 70%, are the average of the estimated delivery ratios for the monitored streams excluding Westfield Creek. Westfield Creek is anomalous because the small number of animals assigned to its watershed in the livestock distribution does not reflect the high percentage of cropland that has manure applied to it from outside the Westfield Creek HUC 12. This means that the load estimate from the event monitoring greatly exceeds the load predicted in the *BSR direct BIT.xls* spreadsheet where the loads are the result of animal numbers in the HUC 12.

The approximated delivery ratios for the design flow conditions are 0.35 for the 1% flow rank, 0.01 for the 10% flow rank, 0.001 for the 50% flow rank, and 0.0001 for the 70% flow rank. These values make sense in that one hundred percent delivery to the Big Sioux River doesn't happen during a precipitation event and because the delivery of the load available for washoff should rapidly decrease with the disappearance of the event transport mechanism.

The other values calculated in the 'delivery ratios' worksheet are the average flows based on area for the design flow ranks in the monitored watersheds. These average flows for the design flow rank conditions are 7900 liters/day/acre for the 1% flow rank, 1600 liters/day/acre for the 10% flow rank, 600 liters/day/acre for the 50% flow rank, and 400 liters/day/acre for the 70% flow rank. Again, these values make sense physically; the 1% flow rank represents precipitation events when the flow in smaller streams would be expected to increase dramatically. The 50% and 70% flow ranks represent a base flow that should be more consistent and even within the flow ranks.

There are four other worksheets in each of the spreadsheets *BSR direct allocations and reductions.xls* and *Rock allocations and reductions.xls*. Each of these worksheets calculates the load allocations and the percent load reductions needed for one of the four flow ranks and the associated areal flow estimate by HUC 12.

The stream flow from each HUC 12 is estimated based on discharge per acre times the HUC 12 area. This daily flow rate (liters/day) is multiplied by the water quality standard target of a sample maximum concentration 235 E. coli organisms per 100 milliliters to determine the load allocation for each HUC 12 sub-watershed.

The non-point source loading from the modified BIT spreadsheets has three components that are entered into these worksheets separately:

1. The totalized non-point source daily loads from the event run-off of the four land use categories; cropland, pasture, ungrazed pasture/forest, and built-up. These are the non-point source loads that the delivery ratios are applied to at the different flow ranks. As the flow decreases these loads decrease rapidly.

2. Cattle in the stream loads are generally from grazing cattle that spend some percentage of their grazing time directly in streams where their manure becomes a direct deposit. Cattle in the stream includes any loads from livestock or wildlife that get into the stream when there are not run-off conditions.

   This category changes by the month with the assumptions that no cattle graze December through March and seven percent of the total beef cattle graze April through November (estimate from evaluation of county ag statistics and field assessments in Lyon County). The fraction of the grazing cattle that deposit manure is assumed to be at least 12% from April to

October and twice as high (24%) in the summer months of June, July, and August (estimates from IDALS staff).

3. Failed septic tanks are rural household onsite wastewater treatment systems that generally consist of a septic tank that discharges directly to a ditch or tile. The total number of households was determined from the 2002 census blocks for each county and the number of households in cities with wastewater treatment facilities was subtracted from the total to get the number of rural households.

The 'septics' worksheet in the two BIT spreadsheets, *BSR direct BIT.xls* and *Rock BIT.xls* describe the assumptions and calculations used to estimate the failed septic tank loads. It is assumed that failed septics are distributed evenly across the watershed based on land area. The density for the Rock River watershed is estimated to be 0.006 failed septics/acre and for the Big Sioux direct it is estimated to be 0.008 failed septics/acre. Discussions with IDNR staff responsible for the onsite wastewater treatment systems program suggest that the failure rate for septic tank systems in northwest Iowa is over 90%. This assessment is supported by a survey that was done in nearby Clay County showing that 92% of the onsite septic tanks discharge directly to a ditch or a tile. The fraction of failed septic systems for both Iowa watersheds used for this report is 90%.

The direct contributions of bacteria from failed septics to the Big Sioux River are represented as a point source located at the discharge of each HUC 12 sub-watershed and the die-off is calculated from the HUC 12 discharge to the Big Sioux River as previously described. It is assumed that the load from failed septics is continuous throughout the year and in all flow conditions. The failed septic load from each HUC 12 is translated from fecal coliform to *E. coli* and then put in the 'allocation and reduction' worksheets for the four flow ranks.

The loads from the three categories of non-point sources are totaled and the load allocation is subtracted from this total. This difference is the load reduction needed and it is calculated for each HUC 12 at each of the design flow ranks, 1%, 10%, 50%, and 70%. The percent load reduction needed is also calculated.

The load allocations have been calculated for the month of June because it is representative of some of the highest loadings from the two non-point sources that have seasonal fluctuations. The June non-point source daily loads from event run-off of the four land use categories, while not always as high as in the spring and fall, are still substantial. The estimated fraction of grazing cattle in the streams is as high as it is assumed to get. Together, these loads approach the worst case expected in the Big Sioux watershed at all four of the design flow ranks. There is another reason to use the month of June for the design conditions and that is because almost all of the monitored events occurred then. The data from these events has been important in the calculations used to estimate delivery ratios and areal flow from the HUC 12's at the design flow ranks.